Public Health Assessment for

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BERTRAND CREEK AREA PROPERTIES
(a/k/a NORTH WHATCOM COUNTY
GROUNDWATER CONTAMINATION)
LYNDEN, WHATCOM COUNTY, WASHINGTON
CERCLIS NO. WA0002325850
JUNE 6, 2000

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

PUBLIC HEALTH ASSESSMENT

BERTRAND CREEK AREA PROPERTIES
(a/k/a NORTH WHATCOM COUNTY GROUNDWATER CONTAMINATION)

LYNDEN, WHATCOM COUNTY, WASHINGTON

CERCLIS NO. WA0002325850

Prepared by:

Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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FOREWORD

The Washington State Department of Health (DOH) has prepared this Public Health Assessment in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This Public Health Assessment was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this Public Health Assessment is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. The Public Health Assessment allows DOH to respond quickly to a request from concerned residents for health information on hazardous substances. It provides advice on specific public health issues. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

For additional information or questions regarding DOH, ATSDR or the contents of this Public Health Assessment, please call the Health Advisor who prepared this document:

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ACRONYMS/ABBREVIATIONS

1,2-DCP	1,2-dichloropropane
1,2,3-TCP	1,2,3-trichloropropane
ATSDR	Agency for Toxic Substances and Disease Registry
COC	Contaminant of Concern
CSF	Cancer Slope Factor
DBCP	1,2-dibromo-3-chloropropane
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EDB	ethylene dibromide
EPA	Environmental Protection Agency
LOAEL	Lowest Observed Adverse Effect Level
LTHA	Lifetime Health Advisory
MCL	Maximum Contaminant Level
MRL	Minimal Risk Level
NOAEL	No Observed Adverse Effect Level
PAH	Polycyclic aromatic hydrocarbon
PHA	Public Health Assessment
PHAP	Public Health Action Plan
ppb	parts per billion
ppm	parts per million
RfD	Oral Reference Dose
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WCHHS	Whatcom County Health and Human Services
WWU	Western Washington University

SUMMARY

Purpose and Health Issues

In February 1998, several members of the community in the area of north Whatcom County petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to prepare a health assessment addressing their health concerns related to pesticides found in area groundwater. This health assessment was prepared by the Washington State Department of Health (DOH) under a cooperative agreement with ATSDR and addresses these health concerns.

Background

Investigations of pesticide contamination in north Whatcom County groundwater began shortly after the emergency suspension of ethylene dibromide (EDB also known as 1,2-dibromoethane) as a soil fumigant in September 1983. Concern over the potential for EDB to migrate from soil into groundwater resulted in a health advisory and subsequent groundwater investigations by the Washington Department of Social and Health Services (DSHS) in1984. Several residential and public supply wells in north Whatcom County near the City of Lynden were found to be contaminated with EDB during this investigation. Further groundwater investigations by various federal, state and local agencies throughout the 1980s and 1990s would reveal EDB and other pesticides in two main areas west and northeast of the City of Lynden. In addition to the discovery of pesticide contamination, widespread nitrate contamination of drinking water wells was found throughout the north Whatcom County area.

Contaminants of concern in north Whatcom County groundwater include EDB, 1,2-dichloropropane (1,2-DCP), 1,2-dibromo-3-chloropropane (DBCP), 1,2,3-trichloropropane (1,2,3-TCP) and nitrate. EDB and DBCP were active ingredients in soil fumigant preparations while 1,2-DCP and 1,2,3-TCP were created as by-products during the manufacture of these pesticides. In September 1998, an investigation by the Environmental Protection Agency (EPA) failed to find any specific sources or definite boundaries for these pesticides in groundwater. It is likely that several contaminant plumes exist that are associated with past agricultural use of soil fumigants in various areas. Nitrate contamination is clearly linked to the application of manure and other fertilizers to agricultural lands in the area.

Remedial Actions

Bottled water was the initial remedy chosen in the late 1980s for residents with pesticides in private drinking water wells above regulatory standards, known as maximum contaminant levels (MCLs). A water line was extended in 1988 from the City of Lynden water supply to the Meadowdale Water Association to replace an EDB contaminated well. Health evaluations conducted by the Agency for Toxic Substances and Disease Registry (ATSDR) and the Washington State Department of Health (DOH) in 1998 and 1999, noted that pesticides can volatilize during showering and other household water uses and contribute as much exposure as ingestion. In April 1999, the Washington State Department of Ecology (Ecology) distributed shower-head filters to homes with EDB and 1,2-DCP in drinking water at levels at or above the

MCL. These devices have been shown to remove these pesticides from water. Ecology is currently evaluating long-term solutions for homes with contaminated wells.

Health Effects

Exposure to the pesticides found in north Whatcom County groundwater can occur through ingestion, inhalation and dermal absorption. Non-cancer adverse health effects are not anticipated to result from exposure to the maximum levels of pesticides detected in north Whatcom County groundwater. However, a moderate to low cancer risk was estimated for long-term exposure to the maximum level of EDB detected in area drinking water. Maximum levels of the other pesticides found in area drinking water represent a lower cancer risk. While the MCLs for these pesticides are protective against non-cancer adverse health effects, some cancer risk does exist for residents using wells with EDB and/or multiple pesticides below their respective MCLs. It is important to note that cancer risk estimates made here are based on a worst-case scenario. More realistic exposure assumptions result in considerably lower cancer risk estimates. In addition, pesticide levels are declining in area groundwater indicating that future cancer risk is declining as well.

Elevated nitrate levels have been detected in many area drinking water wells. Pregnant women could be at risk for adverse birth outcomes from exposure to nitrate above the MCL. Infants bottle-fed using formula mixed with water containing nitrate above the MCL are at risk for methemoglobinemia. Ingestion is the only route of exposure that poses a health concern for nitrate in drinking water.

The potential for toxic interaction between nitrate and pesticides in drinking water may also be of concern. While no evidence exists to show that the toxicity of the pesticides evaluated here is potentiated when combined with nitrate, a recent study did find such an interaction in mice dosed with nitrate and different pesticides at levels commonly found in groundwater. In addition, the potential for combined exposure of migrant farm workers to pesticides in drinking water, soil and indoor dust must also be considered. Although pesticides detected in migrant camp wells are below a level of health concern, workers are exposed to elevated nitrate in these wells along with the potential exposure to pesticides in soil and indoor dust.

Conclusions

A public health hazard exists for those residents exposed to pesticides found in drinking water at levels above their respective MCLs. Pesticides in drinking water detected above their respective MCLs pose a moderate to low cancer risk. In addition, a low to very low risk for cancer exists from long-term exposure to EDB or multiple pesticides at levels below the MCL.

A public health hazard exists for pregnant women and bottle-fed infants exposed to nitrate in drinking water at levels above the MCL. Further investigation of the health risks associated with nitrate in drinking water is warranted.

No apparent public health hazard exists for migrant farm workers in north Whatcom County exposed to pesticides in drinking water. Recent sampling indicates that no migrant camp wells are contaminated with EDB while two wells had 1,2-DCP below the MCL. Pesticides in soil and indoor dust may represent an additional exposure pathway for farm workers.

No apparent public health hazard exists for persons exposed to mixtures of pesticides and nitrate in drinking water at or below respective MCLs. However, interactions between nitrate and pesticides commonly found in groundwater should be examined more thoroughly.

Recommendations

North Whatcom County residents using domestic water supplies contaminated with pesticides above the MCL should take steps to reduce both ingestion and inhalation exposure. In addition, residents using drinking water containing EDB or multiple pesticides at detectable levels should consider reducing exposure.

Pregnant women and infants should not drink water containing nitrate above the MCL of 10 ppm. The relationship between exposure to nitrate in drinking water and the risk of methemoglobinemia in infants, as well as adverse birth outcomes, warrants further investigation.

Residents using drinking water with nitrate at or above the MCL *and* detectable levels of pesticides should consider steps to reduce exposure.

Migrant farm workers should take steps to reduce the potential for exposure of themselves and their families to pesticides in soil and indoor dust. In addition, public drinking water wells used to supply migrant farm worker camps should be evaluated for potential impact from pesticide application and/or sampled for pesticides on a regular basis.

PURPOSE AND HEALTH ISSUES

In February 1998, several members of the community in the area of north Whatcom County petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to prepare a health assessment addressing their health concerns related to pesticides found in area groundwater. The petition cited concern for both private well users and migrant farm workers exposed to pesticides in drinking water. Specific concerns noted in the petition include the following: (1) incomplete testing of migrant camp wells; (2) exposure to pesticides in drinking water through bathing and cooking; and (3) an apparent increase in childhood leukemia in north Whatcom County. This health assessment was prepared by the Washington State Department of Health (DOH) under a cooperative agreement with ATSDR and addresses each of these health concerns.

BACKGROUND

A. Site Description and History

Whatcom County is located in the northwest corner of Washington State bordered by British Columbia to the north, Okanagan County to the east, Skagit County to the south and the Straight of Georgia to the west. The county contains 2,151 square miles of diverse terrain stretching from the North Cascade mountains west across fertile agricultural lands to the major seaport of Bellingham (Figure 1).

Groundwater contamination issues emerged in north Whatcom County following a series of federal and state administrative actions beginning in September 1983 with the emergency suspension of ethylene dibromide (EDB, also known as 1,2-dibromoethane) as a soil fumigant by the Environmental Protection Agency (EPA). Following this action, EPA established a health advisory level for EDB at 0.02 parts per billion (ppb) which was adopted by the Washington State Department of Social and Health Services (DSHS) in May 1984. In July 1992, the federal maximum contaminant level (MCL) for EDB was established at 0.05 ppb.[1] This MCL was adopted by DOH as the enforceable regulatory limit for EDB in public drinking water supplies.

Maximum Contaminant Level (MCL)

The MCL is a regulatory limit set by the Environmental Protection Agency (EPA) for contaminants in public drinking water. If an MCL is exceeded, regulatory action is required under the Safe Drinking Water Act. MCLs are not always strictly health based but can consider technological or economic feasibility. The Washington State Department of Health (DOH) regulates public drinking water supplies in Washington State.

B. Demographics and Land Use

Approximately 156,000 people currently reside in Whatcom County. There are two areas of primary concern for groundwater contamination located west and northeast of the City of Lynden

(Figure 2). One is located around Bertrand Creek (Study Area B) and the other is in the neighborhood of Meadowdale (Study Area A). Land use in this area is primarily agricultural and includes several dairy and berry farms. Although farm land decreased by 12 percent from 1992 to 1997, market value from farm produce increased by 27 percent during this same time period.[2] This trend is explained by an increase in residential property within the county agricultural areas along with a switch from dairy farms to more profitable raspberry production.

Figure 3 approximates Study Areas A and B within a 2-mile radius.[a] The actual boundaries of each study area are shown in Figure 2. The population for Study Area B is estimated to be 1,440 with 86 percent of the land used for agriculture.[3,4] The Berthusen Water Association, which receives its water from the City of Lynden, serves approximately 20 percent of the area while smaller community systems supply about 10 percent.[5] The remaining customers are served by at least 198 private wells.[3]

Population for Study Area A is estimated at 820 with 83 percent of the land used for agriculture.[3,4] Approximately 30 percent of water users in the area receive water directly from the City of Lynden while another 20 percent receive city water through the Meadowdale Water Association.[5] The remaining customers are served by at least 52 private wells.[3]

Pesticide Use

The use of pesticides in Whatcom County prior to 1991 is not well documented. Soil fumigants that contained EDB or 1,2-dichloropropane (1,2-DCP) were used on strawberries, raspberries, seed potatoes and other row crops in north Whatcom County and British Columbia. Sources indicate that EDB was used as a soil fumigant as early as the 1970s. Approximately 7,653 gallons of pesticide containing 36 to 78 percent EDB were applied on 416 acres in Whatcom County between 1981 and 1983.[1] Past use of EDB as a grain fumigant is not expected to have been a significant contributor to groundwater contamination. The use of EDB as a gasoline additive could have contributed to groundwater contamination from leaking storage tanks and spills.

The presence of 1,2-DCP contamination in Whatcom County groundwater is likely due to past use of soil fumigant formulations that contained as much as 25-30 percent 1,2-DCP along with the active ingredient 1,3-dichloropropene (1,3-D). This formulation was marketed as Shell DD and Dow Vidden D between 1956 and 1962. In 1962, Dow Chemical introduced the soil fumigant Telone which contained only 12 percent 1,2-DCP. By 1998, manipulations of the Telone formulation resulted in a product with only 0.05 percent 1,2-DCP called Telone II.[6]

The presence of 1,2-dibromo-3-chloropropane (DBCP) in area groundwater is likely due to past soil fumigation practices that took place prior to 1977, when this use was banned on all crops except pineapples. All uses of DBCP were banned by 1985.[7] 1,2,3-Trichloropropane (1,2,3-

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[a]The highest detected level of EDB is the center point for Study Area B in Figure 1 while the center point for Study Area A is the point equidistant between the only two detections of EDB in that area. These radii are theoretical boundaries designed to provide demographics for the areas of highest contamination.

TCP) was never used as a pesticide but is a by-product of 1,3-D production.[8] The presence of 1,2,3-TCP in area groundwater is likely the result of past Telone use.
Information on the current use of pesticides in Whatcom County was requested from the Whatcom Farmers Cooperative. However, no data were obtained by the time this document was released. DOH will continue to pursue this information in order to update the final release of this health assessment.

Groundwater Characterization

The study areas in which pesticide contaminants have been found in north Whatcom County groundwater are located within the boundaries of the Sumas-Blaine aquifer. This shallow aquifer covers approximately 150 square miles around the City of Lynden and is the principal groundwater source for the area (Figure 4). Groundwater generally moves toward the Nooksack River and its tributaries (Figure 5). The aquifer can range up to 75 feet in thickness with a very shallow water table usually lees than 10 feet below ground surface. Groundwater flows rapidly in this aquifer at rates ranging from 20 to 300 feet per day. [6,9]

C. Nature and Extent of Contamination

Since initial concern over EDB was raised in 1983, several groundwater investigations, focusing on both pesticides and nitrates, have been conducted in the north Whatcom County area. Between June and October 1984, 35 residential and public water supply wells were sampled by DSHS and analyzed for EDB, nitrate and bacteria. Wells were selected based on proximity to pesticide application areas. According to the DSHS report, five of these wells tested positive for EDB with a maximum detection of 4.3 ppb.[1] These data were evaluated in a report released by Ecology in June 1986 that provided an extensive assessment of EDB. The Ecology document also provided more detailed information on the DSHS sampling and reported a total of eight wells with EDB contamination. Levels of EDB in each of these wells exceeded the current health advisory level of 0.02 ppb with two of these wells also showing nitrate above the MCL of 10 parts per million (ppm). Five of the contaminated wells were noted to be public water supplies, four of which served migrant farm worker camps with the fifth identified as the Meadowdale Water Association well.[10]

A study conducted by Western Washington University (WWU) between 1986 and 1991, found EDB above the former health advisory level of 0.02 ppb in 18 of the 107 wells sampled with a maximum detection of 6.2 ppb. During this study, one residential well was sampled monthly for 27 months (max EDB at 2.3 ppb) in order to assess the impact of rainfall and time on EDB levels. The authors concluded that recent rainfall events can dilute EDB in groundwater and that EDB levels in this well would not reach 0.02 ppb until 2012.[11]

The next major sampling effort was made by the United States Geological Survey (USGS) in 1990 as part of the LENS Groundwater Study organized by Whatcom County Health and Human Services (WCHHS) under a grant from the Washington State Department of Ecology (Ecology). In July 1993, as part of the educational and public involvement portion of the LENS study,

residents in the sampling area were offered a free nitrate test that resulted in 304 sample analyses with 54 exceeding the MCL.[12]

Between 1991 and 1994, Ecology and DOH took 63 samples from 23 private and public supply wells located in Study Area A and B. Further sampling by these two agencies took place between April and November 1998 that included 203 samples from 156 wells.[5,13] In response to a citizen petition filed in February 1998, EPA conducted soil, sediment, surface water and groundwater sampling later that year to identify the extent and potential sources of contamination. Groundwater sampling consisted primarily of temporary groundwater probes along with the sampling of four drinking water wells. A contaminant source was not identified, leading to the conclusion that "the contamination could have been the result of agricultural application."[14] The USGS also sampled monitoring and drinking water wells in 1998 but has not yet released a report of their findings. However, several drinking water well sample results from this investigation are included in the WCHHS database.

Table 1 below gives the results of all drinking water well testing between 1984 and 1999 for contaminants of concern that have been compiled by WCHHS. In addition to agency sampling, many records of private well tests were gathered by WCHHS and are included in their database. It should be noted that not all samples taken during this period were analyzed for the same contaminants. Some samples were analyzed for only one contaminant while others were analyzed for multiple contaminants including pesticides, nitrate, coliform and volatile organic compounds (VOCs).

Table 1. Contaminants of Concern Detected in North Whatcom County Drinking Water Wells between 1984 and 1999[a]

Contaminant	Maximum Contaminant Level (MCL) (ppb)	Number of Samples	Number of Detections	Number of Detections Above MCL	Maximum Concentration (ppb)	Average[b] Concentration (ppb)
Ethylene dibromide (EDB)	0.05	444	126	98	6.1	0.3
1,2-Dichloropropane (1,2-DCP)	5	293	106	33	28.4	1.7
1,2-dibromo,3-chloropropane (DBCP)	0.2	132	10	3	0.3	0.01
1,2,3-Trichloropropane (1,2,3-TCP)	NA[c]	118	24	NA	2.4	0.22
Nitrate[d]	10 ppm	2619	1186	122	56 ppm	1.9 ppm

a = Sample results based on data compiled by WCHHS and does not include all sampling during this period.
b = Average calculated with non-detects as zero.
c = EPA push-probe sampling in 1998 detected 1,2-DCP as high as 51.4 ppb.
d = No MCL exists for 1,2,3-TCP. EPA has established a Lifetime Health Advisory Level of 40 ppb.
e= Nitrate data represents the entire county. Levels near Bertrand Creek and Meadowdale are considerably higher as shown in Figure 8.
Note: Pesticide concentrations given in parts per billion (ppb). Nitrate concentrations given in parts per million (ppm).

Figures 6, 7 and 8 show the most recent results for EDB, 1,2-DCP and nitrate for all drinking water wells sampled between 1991 and 1999. The large number of data points shown for nitrate in Figure 8 includes hundreds of new wells installed across Whatcom County during this time period. Nitrate testing is required for new drinking water wells along with other water quality parameters that do not include pesticides or VOCs.

Levels of pesticides in north Whatcom County appear to be declining since initial testing in 1984. Charts 1 and 2 below show the change in EDB and 1,2-DCP concentrations over time in two private wells located on Birch Bay-Lynden Road that have had historically high levels of contamination. As can be seen in these charts, levels of contaminants in these wells have declined over the past 10 years. This trend is expected to continue since EDB is no longer used as a soil fumigant and 1,2-DCP is only a minor contaminant in the current soil fumigant formulation known as Telone II.

Chart 1. 1,2–Dichloropropane in a Residential Drinking Water Well on Birch Bay-Lynden Road

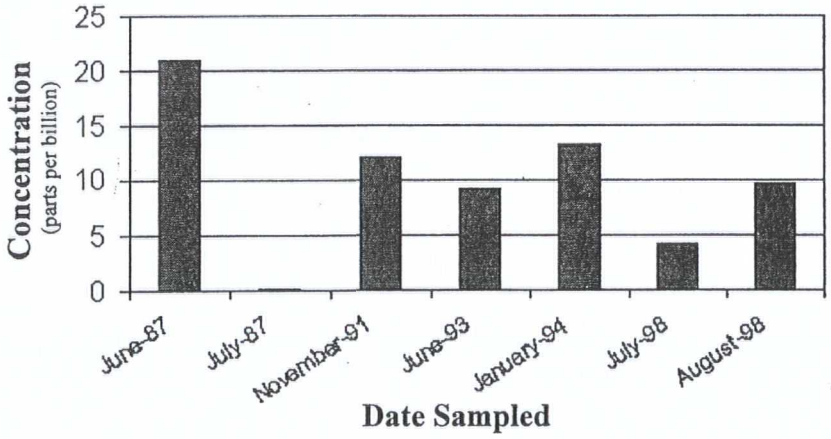
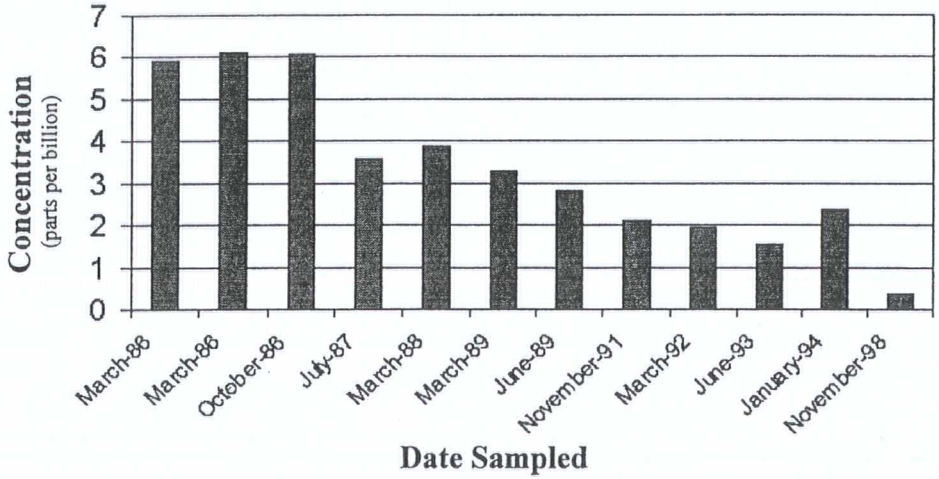


Chart 2. Ethylene Dibromide in a Residential Drinking Water Well on Birch Bay-Lynden Road



The location and boundaries of groundwater contaminant plumes have not been established. Most of the EDB and 1,2-DCP found to date is concentrated in the two study areas. However, as can be seen in Figures 6 and 7, detections of EDB and 1,2-DCP have been found in wells outside these areas. These two contaminants do not appear to be contained in one uniform plume and may exist in several localized pockets associated with historical application of soil fumigants. Detections of DBCP and 1,2,3-TCP are limited but do indicate that these contaminants are also declining in groundwater. Their presence is strongly correlated with 1,2-DCP which has been detected in every sample that has shown either DBCP or 1,2,3-TCP contamination.

Nitrate concentrations will fluctuate in individual wells depending on rainfall, proximity to farm lands and fertilizer application rates. These factors make overall nitrate trends in the Sumas-Blaine aquifer difficult to predict. An increase in manure production between 1985 and 1995 along with a switch from higher to lower nitrate requiring crops (e.g., grass/hay to raspberries) indicates that contamination will continue. Monitoring of wells near dairy farms have shown increases in nitrate associated with application of dairy waste to fields. Ecology monitored nitrate levels in wells along Pangborn Road before and after a 24,000 gallon manure application on an up gradient 5.5 acre field in February 1994. Sampling over the next 3 years revealed that nitrate levels rose from below 10 ppm to nearly 30 ppm before declining back to original levels.[15] This study indicates that nitrate can flush out of groundwater within 3 years if the source is removed.

Migrant Farm Worker Camp Wells

Migrant farm worker camp wells have been sampled several times since 1984. Table 2 below gives the sampling history of these wells. Only one camp (Ehlers) has shown consistent detections of EDB with a maximum of 0.054 ppb. The most recent sampling of all farm worker camp wells in April 1999 did not detect EDB in any well. Two camp wells (Ehlers and Enfield) continue to show 1,2-DCP below the MCL with an overall maximum of 3.9 ppb. Although sampling has been sporadic and it is difficult to discern a trend in the data, levels of 1,2-DCP appear to be declining in these two wells since initial sampling. Nitrate levels as of April 1999 are either near or above the MCL in each camp well except for the Hicks well.

Table 2. Contaminants of Concern in Migrant Farm Worker Camp Drinking Water Wells

Farm Worker Camp	Ethylene Dibromide (EDB)		1,2 – Dichloropropane (1,2-DCP)		Nitrate	
	Date Sampled	Results (ppb)	Date Sampled	Results (ppb)	Date Sampled	Results (ppm)
Ehlers	4/1/99	ND	4/1/99	1.8	4/1/99	12.0
	2/1/94	0.04	2/1/94	3.5	1/31/94	25.8
	1/31/94	0.04	1/31/94	3.5	6/18/93	11.6
	6/18/93	0.03	6/18/93	2.3		
	7/5/89	0.05				
	6/30/88	0.05				
	6/30/88	0.054				
Rader Farms	4/1/99	ND	4/1/99	ND	4/1/99	21.4

Table 2. Contaminants of Concern in Migrant Farm Worker Camp Drinking Water Wells

Farm Worker Camp	Ethylene Dibromide (EDB)		1,2 – Dichloropropane (1,2-DCP)		Nitrate	
	Date Sampled	Results (ppb)	Date Sampled	Results (ppb)	Date Sampled	Results (ppm)
	6/30/88	ND				
Enfield Farms	4/1/99	ND	4/1/99	1.4	4/1/99	9.9
	5/21/96	ND	9/28/95	3.9	9/30/98	8.7
	6/30/88	ND [a]			3/14/97	16.4
Maberry Packing Site	4/1/99	ND	4/1/99	ND	4/1/99	9.8
	2/11/98	ND	2/16/98	ND		
	9/8/88	0.01				
	9/11/84	ND				
Zamudio	4/1/99	ND	4/1/99	ND	4/1/99	12.1
	6/30/88	ND				
	6/30/88	ND				
Hicks	6/16/99	ND	6/16/99	ND	6/16/99	1.7
	6/30/88	ND				
	6/30/88	ND				

a = This sample was split between the local health department which found no EDB and WWU which found 0.104 ppb EDB. Subsequent testing pertains to a new well installed sometime after this initial EDB testing.

Previous Health Evaluations

Several health evaluations have already been conducted by both DOH and ATSDR with respect to groundwater contamination in north Whatcom County. ATSDR reviewed the toxicity and potential for dermal and inhalation exposure to EDB and 1,2-DCP in a report released in July 1998. The report concluded that inhalation and dermal exposure during cooking and bathing could pose as great a health threat as that of ingestion.[16] This report was followed shortly thereafter by a DOH health assessment that noted nitrate as the primary chemical of concern and that the MCL for EDB, 1,2-DCP and DBCP was protective of health. This assessment recommended that residents with wells exceeding the MCL for any contaminant consider water treatment or a new water source. The DOH assessment also recommended that those wells exceeding 5 ppm nitrate (i.e., one-half the MCL) should be tested frequently.[17]

In order to better assess the potential for inhalation exposure to VOCs, ATSDR took air samples in bathrooms following shower use at two residences with 1,2-DCP levels above the MCL. Sampling results indicate that breathing 1,2-DCP in air during and after a shower can result in a dose equal to or higher than that received from drinking the same water. This investigation also demonstrated that a simple carbon filter installed on the shower head, combined with a moderately reduced water flow, could reduce inhalation exposure by approximately 95 percent. Reduced water flow in conjunction with an exhaust fan reduced 1,2-DCP levels in air by more than 50 percent. The investigators concluded that similar results could be expected for EDB and recommended that residents consider "corrective action to minimize inhalation exposures to 1,2-DCP and EDB from contaminated well water during showering."[18]

In July 1999, DOH released the results of a survey examining a possible association between pesticides in drinking water and an increased rate of childhood leukemia (acute lymphocytic leukemia or ALL) in the north Whatcom County area. This survey found no common patterns of exposure in the children with ALL.[19] The survey is discussed further in the Health Outcome Data section (see page 23).

Remedial Actions

In response to the detection of EDB in residential and public wells in 1984, Ecology began seeking alternative water supplies for residents served by the Meadowdale Water Association (Study Area A) and private wells in both areas that showed contamination. A water line was extended from the City of Lynden water supply to the Meadowdale Water Association in 1988 to replace water formerly obtained from an EDB-contaminated well. In addition, Ecology supplied bottled water upon request to homes in that part of Study Area B where EDB was known or suspected to be present in drinking water. By September 1998, the number of homes receiving bottled water had expanded to 67.[5]

In April 1999, Ecology distributed shower head filters to residences that had levels of EDB and/or 1,2-DCP above their respective MCLs. These filters are intended to reduce the amount of EDB or 1,2-DCP that can be inhaled or absorbed through the skin during a shower. Greater than 99 percent removal efficiency of EDB and 1,2-DCP from shower water has been previously demonstrated. WCHHS took water samples between April and July from a residence before and after treatment with a carbon shower-head filter. The results of this sampling are given in Table 3 below. As can be seen from the House A data, removal efficiency after 90 days decreased suggesting that the filter was nearing saturation and highlighting the need for regular replacement. Other concerns that could impact removal efficiency include fouling by high mineral content in water (i.e., hardness) and accumulation of bacteria.

Table 3. Results of 1,2-Dichloropropane Sampling in Shower Water Before and After Carbon Filtration (parts per billion)

	House A			House B		
Day	Before	After	Percent Removal	Before	After	Percent Removal
0	22.4	< 0.02	> 99.9	11.8	0.06	99.5
30	21.1	< 0.09	> 99.6	12.1	0.2	98.3
60	24.0	0.2	99.2	12.6	0.3	97.6
90	18.6	2.1	83.3	NA	NA	NA

PUBLIC HEALTH IMPLICATIONS

A. Introduction

The following sections discuss exposure to the pesticides and nitrate found in north Whatcom County groundwater and the potential health effects that may result. Health effects are separated into cancer and non-cancer endpoints. Methods for assessing these types of health effects are described below.

Evaluating Non-cancer Risk

In order to evaluate the potential for *non-cancer* adverse health effects that might result from exposure to contaminated media (i.e., air, water, soil, and sediment), a dose is estimated for each contaminant of concern. These doses are calculated for situations (scenarios) in which residents might come into contact with the contaminated media. The estimated dose for each contaminant under each scenario is then compared to ATSDR's minimal risk level (MRL) or EPA's oral reference dose (RfD). MRLs and RfDs are doses below which non-cancer adverse health effects are not expected to occur (so called "safe" doses). They are derived from toxic effect levels obtained from human population and laboratory animal studies. These toxic effect levels can be either the lowest observed adverse effect level (LOAEL) or a no-observed adverse effect level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse health effect is seen, while the NOAEL is the highest dose that does not result in any adverse health effects.

Because of the uncertainty in these data, the toxic effect level is divided by "safety factors" giving the lower and more protective MRL or RfD. If a dose exceeds the MRL or RfD, this indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded. If the estimated exposure dose is only slightly above the MRL or RfD, then that dose will fall well below the toxic effect level. The higher the estimated dose is above the MRL or RfD, the closer it will be to the toxic effect level.

Evaluating Cancer Risk

Some chemicals have the ability to cause *cancer*. Cancer risk is estimated by calculating a dose and multiplying it by a cancer potency factor, also known as the cancer slope factor. Some cancer potency factors are derived from human population data; others are derived from laboratory animal studies involving doses much higher than are encountered in the environment. Use of animal data require extrapolation of the cancer potency obtained from these high dose studies down to real-world exposures. This process involves much uncertainty. Current thinking suggests that there is no "safe dose" of a carcinogen and that a very small dose of a carcinogen will give a very small cancer risk. Cancer risk estimates are, therefore, not *yes/no* answers but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat since any level of a carcinogenic contaminant carries an associated risk. The validity of the "no safe dose" assumption for cancer-causing chemicals is not

clear. Some evidence suggests that certain chemicals considered to be carcinogenic must exceed a threshold of tolerance before initiating cancer.

This document describes cancer risk qualitatively using terms like *moderate, low, very low, slight* and *no significant* increase in cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of one cancer case per ten thousand persons exposed over a lifetime. A very low increase might result in one cancer case per several tens of thousands exposed over a lifetime while a slight increase would require an exposed population of several hundreds of thousands to result in a single case. DOH considers cancer risk to be not significant when the estimate results in less than one cancer per one million exposed over a lifetime. The reader should note that these estimates are for *excess* cancers that might result in addition to those normally expected in an unexposed population.

Cancer is a common illness and its occurrence in a population increases with age. Depending on the type of cancer, a population with no known environmental exposure could be expected to have a substantial number of cancer cases. There are many different forms of cancer that result from a variety of causes. Some forms of cancer are more serious than others and not all are fatal. Approximately one quarter to one third of people living in the United States will develop cancer at some point in their lives.

B. Pesticides in Groundwater

Pesticides have been detected in private and public drinking water wells in the north Whatcom County area since 1984. The pesticides of concern are EDB, 1,2-DCP, DBCP and 1,2,3-TCP although other pesticides have been detected infrequently.

Routes of Exposure

The most obvious route of exposure to the pesticides of concern in drinking water is ingestion. However, the ability of these chemicals to volatilize from water makes them available for inhalation from indoor air particularly during bathing and showering. Breathing these pesticides from indoor air can contribute as much or more to the total dose than that of ingestion. Dermal absorption from water during normal household use is expected to contribute only a small fraction of the total dose. The contribution of each route of exposure to the overall dose of EDB and 1,2-DCP is illustrated in Chart 3 below.[b] It should be noted that one study measured a dermal dose of chloroform during a shower that was similar to that of inhalation, suggesting that the modeled dermal dose shown in Chart 3 may underestimate dermal exposure.[20]

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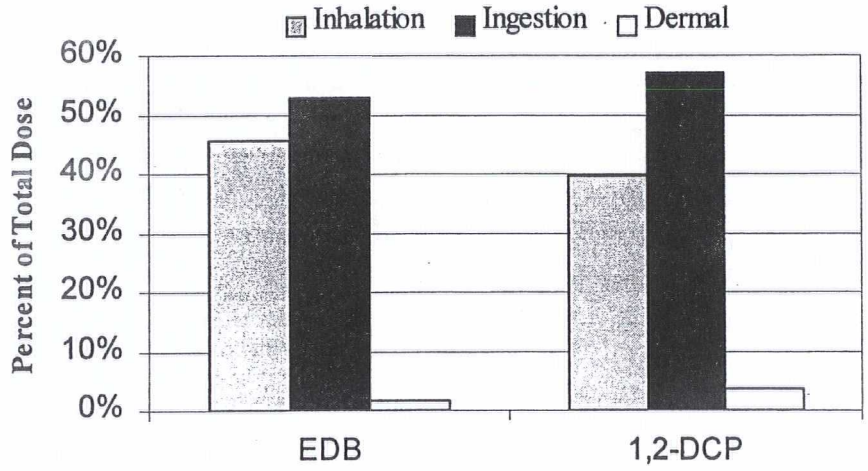
[b] Inhalation dose calculated using a modeled bathroom air concentration following a shower. The modeled air level for 1,2-DCP agreed quite well with actual measurements made by ATSDR at two homes with 1,2-DCP contaminated wells. Inhaled dose could actually be higher due to sources other than showering/bathing.

Chart 3. Route of Exposure Comparison for 1,2-Dichloropropane and Ethylene Dibromide in Drinking Water



Non-cancer Effects

Non-cancer adverse health effects are not expected to result from exposure to pesticides at levels found in north Whatcom County groundwater. Doses were estimated for a young child exposed through ingestion, inhalation of vapors and dermal contact to the maximum detected levels of EDB, 1,2-DCP, DBCP and 1,2,3-TCP found in drinking water (Appendix B, Table 4). None of the doses calculated for these pesticides exceed their respective MRLs or RfDs.[21] Using a child exposure scenario is expected to be protective of the general population. Children are often the most sensitive population with respect to chemical exposure since they ingest more water, contact more soil and breathe more air per unit of body weight than adults. Children are also susceptible to developmental toxicity that can occur at levels of exposure much lower than those causing other types of toxicity.

RfDs and MRLs

Oral reference doses (RfDs) and minimal risk levels (MRLs) are levels of exposure to chemicals below which non-cancer effects are not expected. MRLs are set by ATSDR for acute, intermediate and chronic exposure. EPA sets RfDs based on chronic exposure only. An MRL or RfD is derived by dividing a LOAEL or NOAEL by "safety factors" to account for uncertainty and provide added health protection.

An RfD or MRL was not available for EDB. Therefore, the estimated EDB dose was compared with a lowest-observed adverse effect level (LOAEL). This LOAEL is based on sperm abnormalities in bulls given high doses of EDB in their diet and is 5,600-fold higher than the EDB dose estimate.[22] In other words, the lowest dose of EDB that caused any health effects in animals is still 5,600 times higher than what was calculated for a resident drinking the maximum level of EDB found in north Whatcom County drinking water. Toxicity information on each pesticide of concern is provided in the Chemical Specific Toxicity section located on page 20.

The combined effect of these pesticides was considered by *adding* the estimated doses. This combined dose did not exceed a "combined" RfD (also known as a hazard index). It is important to note that some chemicals can cause more than an additive effect when combined, in which case this assessment will underestimate the potential for adverse health effects. There is little evidence, however, of such *synergistic* effects between chemicals at levels commonly found in the environment. The potential for interactions among chemical mixtures is addressed further below.

Since pesticide levels in north Whatcom County wells are declining, using maximum concentrations detected in drinking water will overestimate current and future exposure for most if not all residents. However, pesticide levels could have been higher prior to initial testing. No information could be located with respect to when soil fumigants containing EDB and 1,2-DCP were first used in north Whatcom County. Since EDB was available in the early 1970s and 1,2-DCP in 1956, the potential exists for several years of exposure prior to initial testing.

Cancer Effects

Of the four pesticides evaluated as contaminants of concern in north Whatcom County drinking water, only EDB is currently classified by EPA as to its carcinogenicity. EDB is a Group B2 probable human carcinogen based on its ability to cause cancer in animals at high doses. These animal studies have shown EDB to be a potent carcinogen by all routes of exposure causing a wide variety of tumors including cancers of the forestomach, lung, nasal cavity, mammary glands and blood vessels of various organs. However, there is currently no evidence to show that levels commonly found in the environment can cause cancer in humans. The potential for chemicals to cause cancer in humans is often assessed by evaluating workplace exposure. Two studies of workers exposed to EDB primarily through inhalation at manufacturing plants found no statistically significant increase in mortality.[22,23]

Although EPA has withdrawn the cancer classification for 1,2-DCP, DBCP and 1,2,3-TCP, each of these pesticides was formerly considered a Group B2 probable human carcinogen based on long-term animal exposure studies carried out by the National Toxicology Program (NTP). As with EDB, there is no evidence that these three pesticides can cause cancer in humans although studies are limited.[7,8,24] The available cancer data for these pesticides are discussed in the Chemical Specific Toxicity section located on page 19.

The relevance of cancer found in high dose laboratory animal studies for humans exposed to much lower levels found in the environment is questionable. Such animal data are considered to be much stronger when supported by evidence of cancer in humans. In order to relate these high dose animal exposures to the lower environmental exposures experienced by humans, estimates are made using mathematical equations. These mathematical equations are used to derive cancer slope factors (CSFs) that are measures of cancer potency and can be used to estimate risk. Cancer risk estimates in this health assessment utilized CSFs derived by EPA from animal data. A

discussion of cancer risk estimation is given in the introduction of the Public Health Implications section located on page 11.

Cancer risk estimates for each of the four pesticides noted as contaminants of concern are given in Appendix B, Table 5. These risks were estimated for long-term (i.e., 30 years) exposure of a child/adult using water contaminated with the maximum detected level of each pesticide. An evaluation of these estimates indicates that EDB at a level of 6.1 ppb carries a *moderate to low* increase risk of cancer. Maximum levels of the other pesticides are categorized as a *low to very low* increased risk of cancer.

Cancer Risk

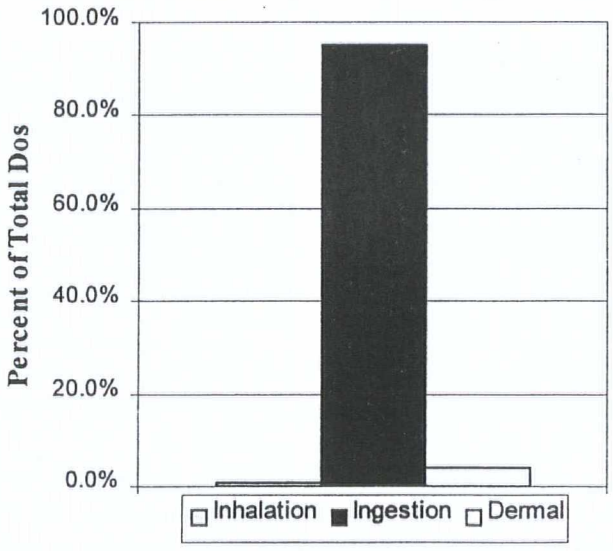
Cancer risk estimates do not reach zero no matter how low the level of exposure to a carcinogen. Terms used to describe this risk are defined below as the number of excess cancers expected in a lifetime:

Term		# of Excess Cancers
moderate	is approximately equal to	1 in 1,000
low	is approximately equal to	1 in 10,000
very low	is approximately equal to	1 in 100,000
slight	is approximately equal to	1 in 1,000,000

The most recent comprehensive sampling of wells by DOH in November 1998 revealed a maximum level of EDB more than 10-fold lower than the overall maximum used above to estimate cancer risk. Only two of 22 wells sampled during this period contained detectable levels of EDB. The other pesticides of concern were also detected infrequently and at very low levels during this recent sampling. Since EDB contributes the majority of the cancer risk estimated above, it is apparent that overall cancer risk has declined significantly. However, even at the MCL, the high potency of EDB as an animal carcinogen translates into a *low to very low* cancer risk.

It is useful to note that the high cancer potency of EDB is attributed to the formation of forestomach tumors in rats and mice exposed by the ingestion route while potency via inhalation appears to be much lower. This discrepancy is illustrated in Chart 4 which shows the distribution of cancer risk by route of exposure. Considering this difference, the supply of bottled water to residents with EDB contaminated wells may have provided a greater reduction in cancer risk than is apparent from a simple comparison of dose and exposure route.

Chart 4. Ethylene Dibromide Cancer Risk by Route of Exposure



Many drinking water wells have only low levels of 1,2-DCP that do not pose a significant cancer risk to residents using these wells for drinking and other domestic uses. However, wells with higher levels of 1,2-DCP

(e.g., > MCL) or multiple pesticides can pose a *low to very low* cancer risk regardless of the presence of EDB. Pesticide sampling data indicate the presence of 1,2-DCP in every sample that contained 1,2,3-TCP or DBCP.

Exposure to the levels of pesticides found in many north Whatcom County wells is considered to be below a level of health concern for both cancer an non-cancer endpoints. In addition, cancer risk associated with pesticides at levels of health concern is likely overestimated. There is no evidence that this level of pesticide exposure can cause cancer in humans. We encounter cancer risk every day from both natural and man-made carcinogens in our food, air and water. It is useful to consider these "background" exposures to better understand the relative risks associated with the pesticides in north Whatcom County drinking water wells.

C. Nitrate in Groundwater

Routes of Exposure

The only route of exposure considered to be significant for nitrate in drinking water is ingestion. Nitrate will not volatilize from water and the amount of dermal absorption compared to ingestion is expected to be minimal.

Non-cancer Effects

Ingestion of drinking water containing nitrate at or above the MCL of 10 ppm may pose a health hazard for infants due to the risk of methemoglobinemia. A risk for adverse birth outcomes also exists for pregnant women drinking water that contains nitrate above the MCL.

Nitrate varies widely in north Whatcom County drinking water wells. Of the 2,619 nitrate test results compiled by WCHHS, 122 exceeded the MCL of 10 ppm with a maximum of 56 ppm. The estimated dose of an infant ingesting 0.6 liters per day of formula prepared with drinking water containing nitrate at the MCL of 10 ppm is equivalent to the RfD for nitrate. This RfD is based on a study that found no methemoglobinemia in infants exposed to nitrate in drinking water at levels below 10 ppm while two percent of infants exposed at 11-20 ppm showed early clinical signs of this disorder. Most studies show that nitrate levels below 20 ppm will not result in symptoms or adverse health effects unless accompanied by a large dietary nitrate source or simultaneous exposure to bacteria. Bacteria in the digestive tract can enhance the conversion of nitrate to nitrite.[21] A recent literature review suggests that bacterial and viral infections of the digestive system (i.e., gastroenteritis) may be the cause of many infantile methemoglobinemia formerly attributed to nitrate in drinking water.[25]

Nitrate-induced methemoglobinemia is caused by decreased oxygen delivered to body tissue by the blood and is directly related to the conversion of nitrate to nitrite in the body. Infants are more susceptible to nitrates in drinking water because of a relatively high fluid intake and increased levels of fetal hemoglobin compared with older children and adults. Fetal hemoglobin is more easily converted to methemoglobin than is the adult form. At very high levels of exposure,

the decreased oxygen availability to the tissues can cause a serious condition called "blue baby" syndrome. This syndrome is often difficult to diagnose but is indicated by a bluish color around the lips, hands and feet. Other symptoms can include lethargy, sweating, flushed skin, vomiting and diarrhea that are easily confused with other common ailments. "Blue baby" syndrome can be diagnosed directly by measuring the amount of methemoglobin in the blood. Death can result if severe cases are not recognized and treated. [26]

Some animal studies have shown a relationship between adverse birth outcomes and nitrate in drinking water but only at high doses.[27] A LOAEL was derived from a study that found impaired neurobehavoiral development in rats given relatively low doses of nitrate *in utero* and as pups. An estimated dose for a pregnant women drinking water containing nitrate at the MCL of 10 ppm is approximately 20 fold lower than this LOAEL. This comparison suggests that nitrate at or below the MCL is not a concern for developmental effects. Such a comparison assumes dietary intake and nitrate/nitrite metabolism are similar between the rat and human.

There is some evidence that pregnant women who drink water contaminated with nitrate are at risk for adverse birth outcomes. A recent study showed that nitrate levels above 20 ppm may be associated with increased spontaneous abortions.[28] Another study showed a significant increase in birth defects associated with nitrate in drinking water at 5-15 ppm.[29] The latter association could not be attributed solely to nitrate exposure since other chemicals including pesticides were likely present in the drinking water. These and other studies examining the relationship between nitrate in drinking water and birth defects remain inconclusive.[30,31]

Cancer Effects

EPA has not classified the cancer potential of nitrate. There is evidence that the body can convert nitrite into cancer-causing nitrosamines. It has been postulated, therefore, that nitrate in drinking water could lead to increased cancer risk via conversion into nitrite and the subsequent formation of nitrosamines. Exposure of rats to *nitrite* in drinking water along with concurrent exposure to nitrosable amines has been shown to cause an increase in digestive tract tumors attributed to the formation of nitrosamines in the body. However, this increase was not seen in rats exposed to *nitrate* and nitrosable amines. In addition, no increase in tumor formation was seen in rats exposed separately to these nitrosamine precursors. Several human studies have failed to provide clear evidence to support a link between nitrate exposure and cancer.

D. Multiple Chemical Exposure

In almost every situation of environmental exposure, there are multiple contaminants to consider. The potential exists for these chemicals to interact in the body and increase or decrease the potential for adverse health effects. The vast number of chemicals in the environment make it impossible to measure all of the possible interactions between these chemicals. Individual cancer risk estimates can be *added* since they are measures of probability. When estimating non-cancer risk, however, similarities must exist between the chemicals if the doses are to be added. Groups

of chemicals that have similar toxic effects can be added such as volatile organic compounds (VOCs) which cause liver toxicity. Polycyclic aromatic hydrocarbons (PAHs) are another group of chemicals that can be assessed as one added dose based on similarities in chemical structure and metabolites. Although some chemicals can interact to cause a toxic effect that is *greater than* the added effect, there is little evidence demonstrating this at concentrations commonly found in the environment.

Some effort has been made to assess the toxicity of chemical mixtures commonly found in groundwater. One group of researchers selected a mixture of 25 chemicals that are frequently found groundwater at hazardous waste sites for administration to mice via drinking water. One study of this mixture examined effects on the immune system while the other looked for reproductive toxicity.[32,33] No adverse reproductive effects were seen while some immune responses were suppressed at the higher doses. Based on previous studies, the authors concluded that these contaminants given alone at the same doses would not have shown immune suppression activity. Although this result is suggestive of potential interactions between contaminants present in drinking water, the doses used in this study were still relatively high compared to what is often found in contaminated water supplies. The relevance to the contamination found in north Whatcom County is also limited since pesticides and nitrate were not among the chemicals in this mixture.

More recent studies have examined the effects of pesticide/fertilizer mixtures commonly found in groundwater. No adverse reproductive or developmental effects were found in rats and mice given mixtures of 1,2-DCP, EDB, DBCP, nitrate and other pesticides in drinking water at levels well above the maximums detected in north Whatcom County groundwater.[34] However, a 5-year study of mice given atrazine, aldicarb and nitrate in drinking water showed immune suppression responses greater than those of mice given any single agent. This finding is supportive of the immune supression noted above for a different chemical mixture. Perhaps more importantly, the drinking water contaminant concentrations used in this study were only 2-3 times higher than their respective MCLs.[35]

The studies noted above provide some evidence that interactions between chemicals in a mixture can result in toxicity that is not apparent from a single agent. However, the mechanisms of these interactions are poorly understood and have not been demonstrated in humans at environmentally relevant exposures. In addition, the mixtures that did elicit immune responses when given in concert did not include the pesticides of concern found in north Whatcom County groundwater. Finally, the study of chemical mixtures is in its infancy and is a recognized deficiency in the toxicological database. While there appears to be no evidence specifically associating the chemical mixtures of concern in north Whatcom County, the limited information cited above suggests that immunological endpoints could be a target of such an exposure.

E. Migrant Farm Workers

Information communicated to DOH by concerned citizens indicates that some migrant farm worker camp workers and their families live year round at the camps in north Whatcom County. In addition, many camp workers are likely to work at other camps with a later crop harvest. Dose estimates for camp workers, therefore, assumed chronic, year-round exposure.

The only pesticide currently present in migrant camp wells is 1,2-DCP detected at a maximum level of 1.8 ppb in April 1999. This level of 1,2-DCP is far below the maximum found in other area drinking water wells. *As noted previously, non-cancer health effects are not expected to result from exposure to the maximum levels of pesticides found in any area well. Cancer risk from exposure to the current levels of 1,2-DCP found in camp wells is not considered to be significant.* Previous detections of EDB in one camp well indicated that a *low or very low* cancer risk existed for those workers exposed over many years to EDB in this well.

An important issue in assessing farm worker exposure is the potential for workers to contact pesticides in soil and indoor dust. Although there is no soil or dust sampling data for north Whatcom County migrant camps, previous studies have demonstrated that these exposure pathways are of concern.[36,37] Workers can be exposed to pesticides in soil through incidental ingestion, dermal contact and inhalation of dust. In addition, families can be exposed in the home when contaminated soil is tracked indoors and accumulates as indoor dust. Exposure of farm workers and their families to pesticides in soil and indoor dust is dependent upon pesticide use, work habits and precautions taken by individual workers and their employers.

Nitrate has consistently been detected in migrant camp wells. Concerns for pregnant women and infants exposed to nitrate above the MCL are addressed above. Also addressed above is the potential interaction between pesticides and nitrate in drinking water. Although pesticides are at low levels in only two of the camp wells, additional exposures from soil and indoor dust could augment the pesticide dose. Interactions between the pesticides found in north Whatcom County groundwater and nitrate are not of concern for reproductive or developmental endpoints. However, recent evidence indicates a potential for adverse effects on the immune system from exposure to commonly uses pesticides and nitrate in drinking water. This finding indicates a need to further investigate the potential for adverse health effects from exposure to both nitrates and pesticides, particularly with respect to the immune system.

F. Chemical Specific Toxicity

Ethylene Dibromide (EDB)

Ethylene dibromide (EDB or 1,2-dibromoethane) was used extensively in the past as a soil fumigant pesticide and leaded-gasoline additive. An EPA ban on EDB use as a soil fumigant in 1984 along with a decline in the use of leaded-gasoline has significantly reduced the amount of

EDB used in the United States. The source of EDB in the north Whatcom County area is thought to be the result of past use as a soil fumigant.

Non-cancer adverse health effects observed following exposure to EDB are largely restricted to high-dose animal studies. Some of the primary target organs for EDB toxicity in animals include the kidney, liver and reproductive systems. However, no MRLs or RfDs have been derived from the available data. Liver and kidney effects have been documented in humans receiving acute, lethal doses but no evidence exists that chronic, low doses in humans can impact these organs. The reproductive toxicity of EDB in animals is supported by evidence of decreased sperm counts and sperm abnormalities found in exposed workers. In addition, adverse effects on sperm are documented in both animals and humans following exposure to DBCP which is structurally similar to EDB. The reproductive system appears to be the most sensitive non-cancer endpoint associated with EDB exposure. The highest level of EDB detected in north Whatcom County groundwater yields a dose that is still well below a LOAEL based on reproductive toxicity in animals.[22]

Cancer is the primary toxic endpoint of concern for EDB exposure. EDB is classified as a B2 probable human carcinogen by EPA based on its very high cancer potency demonstrated in high-dose animal studies. These animal studies have shown that EDB is carcinogenic by all routes of exposure (i.e., ingestion, inhalation and dermal) at both the point of contact and systemically. In addition, EDB is a potent genotoxin showing mutagenic activity in almost every test system studied. There is, however, no evidence that EDB can cause cancer in humans. As noted previously, two studies of workers exposed to EDB found no statistically significant increase in mortality. One of these studies did find an increase in mortality but had several limitations relating to exposure assessment and controlling for alternate exposures.[22,23] These workers likely had considerably higher exposure to EDB than the worst-case exposure assumed for north Whatcom County residents.

The high oral CSF (a measure of cancer potency) of EDB was derived by EPA from an oral gavage study of rats that resulted in a very high frequency of forestomach tumors. Similar tumors were found in mice dosed with EDB in drinking water. A study of rats exposed to high levels of EDB in air showed various tumors of the nasal cavity from which EPA derived an inhalation CSF that is100-fold lower than for the oral route.[22] It is important to note that the oral and inhalation cancer potencies are based on site contact as opposed to systemic tumors suggesting that a combined systemic dose is not appropriate for risk estimation.

One other aspect of EDB toxicity that deserves mention is the chemical interaction between EDB and disulfiram (Antabuse). Antabuse is a drug used to control alcoholism that has been shown to potentiate the toxicity of EDB in rats. Although this synergy of effect has not been seen in humans, persons using Antabuse should take extra precautions to avoid EDB exposure.

1,2-Dichloropropane (1,2-DCP)

1,2-dichloropropane (1,2-DCP) has been used as a solvent, pesticide, photographic processing chemical and as an intermediate in the formation of other chemicals. The likely source of 1,2-DCP in north Whatcom county groundwater is through the past use of soil fumigant pesticides that contained 1,2-DCP as a by-product.

The primary target organs of 1,2-DCP appear to be the liver, kidney and nervous system as demonstrated by high dose oral and inhalation studies in animals. Limited case studies of humans exposed to acute doses of 1,2-DCP also describe adverse impacts on the liver and kidney. However, no evidence was located to suggest that these adverse health effects could occur at lower, more relevant chronic doses. A chronic MRL of 0.09 mg/kg-day was derived by ATSDR based on liver necrosis seen in rats following oral doses of 1,2-DCP.[24] This MRL was used to compare the doses estimated for north Whatcom County residents exposed to the maximum detected level of 1,2-DCP (28.4 ppb) detected in drinking water. As shown in Appendix B, Table 4, this estimated dose, which included all routes of exposure, is about 36-fold below the MRL and 49,000-fold below the actual dose that caused liver toxicity.

EPA has developed an inhalation reference concentration (RfC) of 0.004 mg/m^3 in air for 1,2-DCP that is based on increased cell growth in rat nasal mucosa following chronic high dose inhalation exposure.[24] RfCs are levels of contaminants in air below which adverse health effects are not expected. Since RfCs are based on continuous exposure (i.e., 24 hours/day), they are not appropriate for comparison with a concentration estimated for a shower scenario. Attempts have been made to estimate whole-house levels of VOCs volatilizing to indoor air from all tap water uses.[38] These estimates show that levels in the remainder of the house are generally 100-fold below those found in the bathroom following a shower. Taking this difference into account, the maximum concentration of 1,2-DCP predicted for general indoor air is about three-fold below the RfC and 1000-fold below the toxic effect level upon which the RfC is based.

RfCs

Inhalation reference concentrations (RfCs) are concentrations in air below which non-cancer adverse health effects are not expected to occur. RfCs are set by EPA based on continuous (i.e., 24-hour/day) exposure.

Although EPA has removed its classification of 1,2-DCP as a B2 probable human carcinogen, there is evidence that high doses of 1,2-DCP can cause liver and possible mammary tumors in mice. No evidence was located regarding cancer endpoints and 1,2-DCP exposure in humans.[24]

1,2-Dibromo-3-chloropropane (DBCP)

1,2-Dibromo-3-chloropropane (DBCP) was used primarily as a soil fumigant prior to restrictions and subsequent cancellation of this use by EPA in 1985. Current use of DBCP is limited to the production of other organic chemicals. The source of DBCP in north Whatcom County groundwater is likely from its past use as a soil fumigant.

The male reproductive system is the primary non-cancer toxic endpoint of DBCP exposure. Abnormal sperm, decreased sperm counts and decreased fertility rates have been observed in workers exposed to DBCP primarily through inhalation at pesticide manufacturing facilities. Doses were not well characterized in these studies but are expected to be considerably higher than those experienced by north Whatcom County residents. No decrease in birth rate was found in a Fresno County, CA population exposed to DBCP in drinking water at levels ranging from 0.04-5.8 ppb.[39]

Reproductive toxicity has also been found in animals exposed to high doses of DBCP through both the inhalation and oral routes. In addition to spermatogenic effects, these animals also showed testicular atrophy indicating a more severe effect with increasing dose. High dose animal studies have also shown that DBCP can impact the liver, kidneys, blood, immune and nervous systems. There is little evidence to show that low doses of DBCP can impact these organs systems in humans. An intermediate MRL of 0.002 mg/kg-day was derived by ATSDR based on adverse effects on sperm seen in rats following oral doses of DBCP.[7] This MRL was used to compare the doses estimated for north Whatcom County residents exposed to the maximum detected level DBCP (0.3 ppb) detected in drinking water. As shown in Appendix B, Table 4, this estimated dose, which included all routes of exposure, is about 100-fold below the MRL and 93,000-fold below the actual dose that caused sperm toxicity in rats.

Although EPA has removed its classification of DBCP as a B2 probable human carcinogen, there is evidence that high doses of DBCP administered to rats and mice can cause tumors in multiple organs, including the forestomach and lungs. The sites of tumor formation induced by DBCP in animals are very similar to those induced by EDB. There is no evidence that DBCP can cause cancer in humans.[7] No increase in cancer mortality was found in one study of workers exposed to DBCP at a production and formulation facility.[40] Also, the previously mentioned population in Fresno County, CA exposed to DBCP in drinking water did not show an elevation in leukemia or gastric cancer.[41]

1,2,3-Trichloropropane

1,2,3-Tichloropropane (1,2,3-TCP) has been used as a solvent and as an intermediate in the formulation of other chemicals. The likely source of 1,2,3-TCP in north Whatcom county groundwater is through the past use of soil fumigant pesticides that contained 1,2,3-TCP as a by-product.

Toxic effects of 1,2,3-TCP exposure have not been documented in humans. High dose animal studies show effects on various organs including the liver, kidney, spleen and blood. An oral RfD of 0.006 mg/kg/day has been derived by EPA based on increased liver and kidney weight and a decrease in red blood cells following oral exposure of rats to 1,2,3-TCP.[8] This RfD was used to compare the doses estimated for north Whatcom County residents exposed to the maximum detected level 1,2,3-TCP (2.4 ppb) detected in drinking water. As shown in Appendix B, Table 4,

this estimated dose, which included all routes of exposure, is about 30-fold below the RfD and 62,000-fold below the actual dose that caused increased liver weight.

Although EPA has removed its classification of 1,2,3-TCP as a B2 probable human carcinogen, there is evidence that high doses of 1,2,3-TCP can cause oral, forestomach and possibly other tumors in rats and mice. No evidence was located regarding cancer endpoints and 1,2,3-TCP exposure in humans.[8]

HEALTH OUTCOME DATA

A survey of leukemia rates in the north Whatcom County area was conducted by DOH and WCHHS.[19] The survey was initiated because of a perceived increase in the childhood leukemia rate that was confirmed upon comparison with statewide cancer registry data. The survey examined the possible relationship between identified leukemia cases and pesticides in drinking water. A total of nine cases were identified with questionnaires sent out to six of these families. One of these six cases was not in the area of concern. Based on examination of drinking water data for the five households with cases in the area of concern, no association was found between pesticides in drinking water and the leukemia. The survey concludes that the presence of 1,2-DCP and EDB in drinking water was not a shared risk factor among the children with leukemia.

It is important to note that leukemia was not one of the cancer endpoints found in the high-dose animal studies that provide evidence of many other types of cancers caused by these pesticides. While there is no evidence associating any of these pesticides with cancer in humans, these animals studies provide useful information on the types of cancer that are of concern. One such cancer endpoint is the stomach, which was analyzed in a study of persons exposed to DBCP in drinking water in Fresno County, CA. No increase in gastric (stomach) cancer incidence or mortality was found in this population.[39] DBCP is structurally similar to EDB and causes similar type of tumors in animals including stomach cancer. Levels of DBCP in Fresno County drinking water were similar to the EDB levels found in north Whatcom County. Studies of workers exposed to EDB and DBCP at pesticide manufacturing plants have also failed to find increased rates of cancer or mortality. It should be recognized, however, that these studies are limited by the small number of workers exposed.

While the limited human studies noted above show that low levels of these pesticides in groundwater will not result in a detectable increase in cancer within an exposed population, they do not rule out such a possibility. One major problem associated with investigating small exposed populations is that increases in cancer rates must be very high for them to be detected by epidemiological methods. Any future analysis of cancer rates associated with exposure to pesticides in north Whatcom County groundwater will have to include other exposed populations in order to enhance the statistical power to the study.

COMMUNITY HEALTH CONCERNS

The following community health concerns were gathered from phone calls and one-on-one interviews with residents during an open house meeting at the Lynden Community Center on March 30, 1999. The questions and comments received by DOH are listed below by category and followed by a response. Many of the questions deal directly with issues evaluated in this health assessment and so the reader is referred to appropriate sections of the document.

Health effects

1. I have read that EDB causes cancer or leukemia. My well at home has 1,2-DCP over safe levels and my family still uses the water for bathing and showering. My grandmother used to live in the same house without bottled water and died of cancer. Could the water have been the cause?

There is no evidence that EDB causes leukemia. There is also no evidence to show that EDB has caused cancer in humans. However, EDB and other pesticides found in north Whatcom County drinking water have been shown to be carcinogenic in animals at very high doses. The levels of EDB, 1,2-DCP and other pesticides found in north Whatcom County drinking water do represent an increased cancer risk depending on type of pesticide, concentration, exposure frequency and exposure duration. Please see the Public Health Implications section starting on page 12 for a further discussion on pesticides and cancer.

2. My gamma-GT count is 95 and my doctor told me that a normal level is 32. Alcohol is not the culprit. Does a high gamma-GT count have anything to do with exposure to these pesticides?

Gamma-GT or γ-glutamyltranspeptidase or GGT is a liver enzyme that is activated by liver damage. Increased GGT activity is not specific to the agents or mechanisms that can cause this damage but is a response to a general toxic effect on the liver. Since these pesticides can cause liver toxicity at high doses, it is possible that your GGT increase is related to pesticide exposure. It is not possible to determine by GGT levels alone whether any real liver damage has occurred and what might have been the cause. You should follow the advice of your physician with respect to this clinical test result. Please call Robert Duff toll-free at 1-877-485-7316 or 360-236-3371 if you would like information on physicians in your area who specialize in environmental health.

3. Will grandchildren be at risk from occasional visits?

There are no acute or short-term exposure risks associated with the levels of pesticides found in north Whatcom County groundwater. However, high levels of nitrate exposure in drinking water over a period of weeks, as opposed to years, can pose a threat to the developing fetus and infants.

Non-cancer adverse health effects are not expected from long-term, daily exposure of young children to any level of pesticide found in north Whatcom County drinking water. The low-level cancer risks described in this health assessment are estimates based on daily exposure over a 30-year period to the maximum levels of pesticide detected in area wells. Long-term cancer risk from exposure of your grandchildren over several years of visits will be considerably lower than what is assumed in this assessment. However, some cancer risk does exist depending on type of pesticide, concentration, exposure frequency and exposure duration.

Drinking bottled water is an effective way to reduce exposure to both pesticides and nitrate. However, if there are pesticides in your water, a filtration system may also be necessary to reduce inhalation and dermal exposure. Filtration methods range from simply installing a carbon filter on your shower-head to a point-of-entry (POE) system that treats all water entering your home. Ecology is currently evaluating alternative water options for the area around Bertrand Creek that could involve your home. For information on Ecology's alternative water evaluation, contact Ecology at 360-738-6250. For information on water treatment systems for your home, call the WCHHS at 360-676-6724.

4. Will inhalation of these compounds cause ear, nose and throat problems?

The pesticides found in area groundwater are volatile and can be inhaled as they volatilize from water during showering, clothes/dish washing and other household uses. At much higher air levels than would result from levels found in area drinking water, 1,2-DCP caused increased cell growth in the nasal mucosa of rats while EDB administered to mice in air caused nasal epithelial tumors. As noted in this health assessment, non-cancer adverse health effects are not anticipated from exposure to even the highest pesticide levels detected. However, some cancer risk is associated with exposure to pesticides found in north Whatcom County drinking water depending on type of pesticide, concentration, exposure frequency and exposure duration. This cancer risk is evaluated in the Public Health Implications section starting on page 12.

5. Concern was expressed about high cancer rates in the area.

A survey of childhood leukemia cases in north Whatcom County drinking water was released by WCHHS and DOH in July, 1999. No association between drinking water and elevated leukemia rates was found. However, leukemia is not one of the cancer endpoints that has been associated with the pesticides of concern in area groundwater. This study and other issues associated with measuring cancer in the area are discussed in the Health Outcome Data section on page 24.

6. How can I reduce my risk?

Water treatment systems and drinking bottled water are effective in reducing exposure to pesticides and nitrate in drinking water. It is important to consider both of these options if you have pesticide in your water since you can be exposed through drinking, breathing of vapors and dermal absorption. Ingestion and inhalation during showering/bathing appear to contribute the most to your overall dose. For information on Ecology's alternative water evaluation, contact Ecology at 360-738-6250. For information on water treatment systems for your home, call the WCHHS at 360-676-6724.

7. My 15-year-old daughter may have developed chronic fatigue syndrome. Is it related to the water?

No evidence was located associating nitrates and pesticides with chronic fatigue syndrome. You should consult with you physician for advice about diagnosis and treatment of this condition.

8. What are these contaminants doing to our bodies?

Please read the Public Health Implications section of this health assessment starting on page 12.

9. What are the risks from *current* pesticide applications?

This document evaluated exposure to contaminants in groundwater that likely resulted from past application of pesticides. A profile of pesticides currently applied on raspberry fields (the predominant crop in the north Whatcom County) is provided in Appendix E. Any health risk associated with use of these pesticides is obviously dependant upon exposure. Two possible routes of exposure for residents living near a pesticide-treated filed are via a contaminated drinking water well or drift from a spraying application. Drift is dependant upon several factors including type of application, type of pesticide and weather. Aerial applications are generally the biggest concern for drift. Growers are required to follow label requirements and WSDA regulations that are in place to limit pesticide drift.

Several factors play a role in determining whether a pesticide applied on a field will be a threat to a drinking water well. Among these factors are type of pesticide application (i.e., soil versus foliar), chemical physical properties of the pesticide, amount applied, frequency of application, movement of groundwater, location of drinking water wells and type of aquifer. If you are concerned about pesticides in your well and how to test for them or pesticide exposure in general, please contact the WCHHS at 360-676-6724 or DOH toll-free at 877-485-7316.

10. Can EDB cause muscle aches?

Since most of the toxicological data on EDB is based on animal studies there is no data available for this type of endpoint. The major target organs for EDB toxicity are discussed in the Chemical Specific Toxicity section starting on page 20.

11. How would I know if my health problems are related to EDB?

It is very difficult to associate health effects with chemical exposures. Such associations are usually made when the effect is very unusual and specific to a particular exposure. EDB toxicity is discussed in the Chemical Specific Toxicity section starting on page 20. As noted in this section, the doses at which adverse health effects have been noted in animals are far above those associated with the exposures experienced by north Whatcom County residents.

12. Will one year of exposure at this level be significant?

Non-cancer adverse health effects are not expected from long-term exposure to pesticides in drinking water. Nitrate exposure of pregnant women and infants over shorter time periods does represent a risk for adverse birth outcomes and methemoglobinemia, respectively.

The cancer risk from a one-year exposure of a young child to the pesticides found in drinking water will pose a cancer risk that is 30-fold below the risk estimated under the worst-case scenario presented in the Public Health Implications section starting on page 12. Generally, the shorter the duration of exposure the lower the cancer risk.

Well Testing

13. How can I have my well tested? Why have wells nearby been tested and not mine?

Many wells have been sampled by various agencies for different contaminants. If your well has not been tested, there is a possibility that it will be in the future but you should assume that the responsibility is your own. There is no clearly defined area of groundwater contamination. Wells that are in areas downgradient from former agricultural lands could be at risk for contamination. The nature of this risk will depend upon the type of agricultural use. For example, berry fields present since the early 1980s could be a source of the pesticide contaminants discussed in this health assessment. Dairy farms, however, are a concern primarily for nitrate and coliform.

The WCHHS has information on past and present agricultural land use as well information on certified laboratories that test for the various contaminants of concern. WCHHS can be contacted at 360-676-6724.

14. A renter wants information prior to 1990 about testing of his well. 1,2-DCP was detected at 2.6 ppb in 1990.

If your well sampling results were reported to the WCHHS, you can obtain these from WCHHS at 360-676-6724. Otherwise, you will need to get the information from whoever requested the test.

15. How can we find out about contamination in a well that serves a house we intend to buy?

You should always inquire about the water quality of a well serving a house that you intend to buy. Real estate agents should have information regarding the disclosure requirements of real estate transactions. If you are inquiring about a well in the north Whatcom County area, the WCHHS (360-676-6724) may have test results available. At a minimum, the well should be tested for nitrate and bacteria. If the well is in an area of concern for pesticides (see Figures 2,6 and 7), DOH recommends that the well be tested for EDB, 1,2-DCP, DBCP and 1,2,3-TCP.

The WCHHS has information on past and present agricultural land use as well information on certified laboratories that test for the various contaminants of concern. WCHHS can be contacted at 360-676-6724.

16. What sampling has been done on the City of Lynden's water?

The City of Lynden obtains it water from the Nooksack River and is required to regularly sample and analyze their water supply for a large number of contaminants including the contaminants of concern discussed in this health assessment (i.e., nitrate, EDB, 1,2,-DCP, DBCP and 1,2,3-TCP). None of the pesticides of concern have ever been detected in the City of Lynden or the City of Ferndale water supplies. The most recent sampling of these municipal water supplies was in April 1999. The significant dilution of these pesticides in groundwater after discharge into the Nooksack River, along with their volatile nature, makes it unlikely that they will be detected in water supplies drawing from the river.

17. Who will be sampling in the future?

There may be additional sampling of wells in the area by government agencies. However, well owners should not assume that their well will be sampled in the future. Since there is no clearly defined area of groundwater contamination, well owners need to assess land use around their wells to determine if there is an upgradient source of contamination. Wells that are in areas downgradient from former agricultural lands could be at risk for contamination. The nature of this risk will depend upon the type of agricultural use. For example, berry fields present since the early 1980s could be a source of the pesticide contaminants discussed in this health assessment. Dairy farms, however, are a concern primarily for nitrate and coliform. The WCHHS has information on past and present agricultural land use as well as information on certified laboratories that test for the various contaminants of concern. WCHHS can be contacted at 360-676-6724.

18. A resident expressed concern about past exposure of her two daughters who lived at Mallards Landing from 1980-1991. How can we know if our well was contaminated?

No sampling data were located for the former well at Mallards Landing. According to DOH public drinking water records, this water system has been inactive since August 1979. Century Water Association currently supplies drinking water to Mallard's Landing. This source is listed as being active since February 1980. Periodic testing of this water supply since 1992 has not detected any of the pesticides associated with groundwater contamination in the area. However, no data were located for this system prior to 1992. For more information on the drinking water supply that served residences at Mallards Landing please contact the WCHHS at 360-676-6724.

Filters

19. Will filters work? Is carbon filtration of drinking water effective?

Carbon filtration devices installed on shower heads demonstrated greater than 99 percent effectiveness at removing both EDB and 1,2-DCP from shower water. The effectiveness of one brand of filter over time was previously evaluated for removal of EDB at concentrations of about 2 ppb. Removal efficiencies remained greater than 99 percent until the 12th month when a slight detection of EDB was made corresponding to a 98.9 percent removal efficiency. WCHHS is currently evaluating such a device over a several month period to determine removal efficiencies of 1,2-DCP over time (see Table 3, page 11). In addition, ATSDR measured 1,2-DCP levels in air before and after carbon filtration of shower water and found good removal efficiencies from shower water along with a 95 percent decline in bathroom air levels. These data show that shower filters are effective at removing both EDB and 1,2-DCP.

These devices can, however, be fouled by high mineral concentrations associated with water hardness. In addition, carbon filters can accumulate bacteria after extended use which can then discharge into the water stream. Carbon filtration devices will need to be replaced regularly and more frequently if hard water fouling is evident. It is also important to remember that filters will not remove nitrate. Reverse osmosis treatment systems can do this but are more expensive to both purchase and maintain.

Filtration methods range from simply installing a carbon filter on your shower-head to a point-of-entry (POE) system that treats all water entering your home. Ecology is currently evaluating alternative water options for the area around Bertrand Creek that could involve your home. Information on Ecology's alternative water evaluation and water treatment systems for your home is available at WCHHS (360-676-6724).

20. Will someone test my filtered water to see if the 1,2-DCP detected at 3 ppb is being removed?

The WCHHS has information on certified laboratories that test for the various contaminants of concern and can be contacted at 360-676-6724. Carbon filtration devices can remove more than 99 percent of 1,2-DCP from your water. WCHHS is currently evaluating the effectiveness of these filters over time (see Table 3, page 11). It is important to note that these filters need to be changed according to manufacturer specifications and possibly sooner if the filter is being fouled by high water hardness.

Nitrate

21. Concern was expressed about nitrate and high pH in water served by the Delta Water Association. The association has a notice out that "babies should not drink the water." Concern was also expressed about EDB in this water.

The reason for the notice about babies not drinking water from this system is that it contains nitrate above the maximum contaminant level (MCL) of 10 ppm. The most recent sampling of this water system in April 1999 detected nitrate at 15.9 ppm. Infants could experience a condition known as methemoglobinemia if fed formula that is mixed with water containing nitrate above the MCL. Pregnant women should not drink this water due to the risk of adverse birth outcomes. For more information regarding nitrate toxicity, see page 16 of the Public Health Implications section of this document.

EDB has not been detected in four samples taken from the Delta Water Association water system between 1992 and 1994. Regular VOC sampling of this system has shown no detections of any pesticide associated with north Whatcom County groundwater contamination.

22. What are the levels of nitrates to be concerned about?

The federal limit for nitrate in public water systems, known as the MCL, is 10 ppm. DOH has adopted this standard and considers it to be health protective. For information regarding nitrate toxicity, see page 16 of the Public Health Implications section of this document.

23. A resident expressed concern about the use of manure as fertilizer on a nearby berry field and increasing nitrate concentrations in his well.

Unfortunately, this is not surprising in agricultural areas where shallow wells are located. Many of the wells in the north Whatcom County area have nitrate problems. If the source of the nitrate, whether manure or other fertilizer, continues to be applied upgradient of your well at the same rate, your nitrate problems will likely continue. Bottled water is an effective remedy since ingestion is the only route of exposure that poses a health concern. There are also treatment systems available that will remove nitrate from your water. These systems are expensive to purchase and maintain, however. For information regarding nitrate toxicity, see page 17 of the Public Health Implications section of this document. Information on water treatment systems for your home is available at the WCHHS (360-676-6724).

24. Will nitrate at 12 ppm affect my grandchildren?

It is unlikely that nitrate at this level will affect your grandchildren unless they are infants less than one year of age. However, this level of nitrate is above the MCL and is considered unsafe for infant formula preparation as well as pregnant women. For information regarding nitrate toxicity, see page 17 of the Public Health Implications section of this document.

Farm workers

25. Migrant farm workers do not know if their water is contaminated and are not being informed. Notices are not getting to workers. Bottled water is not being supplied.

DOH and WCHHS have distributed fact sheets to the community in both English and Spanish. This fact sheet explains the results of a DOH assessment of drinking water contamination in the north Whatcom County area.

The necessity of drinking bottled water is dependant upon the nitrate contamination in drinking water supplied to migrant farm worker camps. Pregnant women and infants should not drink water at or above the MCL of 10 ppm. However, showering, bathing and other household uses of water are not of concern. For information regarding nitrate toxicity, see page 16 of the Public Health Implications section of this document.

26. Workers and families are experiencing asthma, headaches, skin lesions, cancer and trauma. Life expectancy is low for farm workers.

Adverse health effects are not anticipated to result from current exposure of north Whatcom County migrant camp workers to contaminants in drinking water. However, past exposure of workers and families over many years to EDB in the Ehlers camp well does carry a low to very low cancer risk. The additional exposure of workers and families to pesticides in soil and indoor dust is also of concern. However, it is unknown whether the symptoms noted in your question or the reduced life expectancy are associated with farm worker exposure. Exposure associated with farm workers is discussed further on page 20 of the Public Health Implications section.

27. What are the effects of exposure to nitrate and pesticides together? Is additional exposure from working in the fields considered for both children and adults?

Exposure to chemical mixtures including pesticides and nitrates is addressed on page 18 in the Public Health Implications section of this document. Exposures specific to migrant farm workers are also addressed in this section on page 20.

28. The assumption that farm workers are not exposed year-round to contaminated drinking water is not accurate. Many families stay year round on the farm as renters or managers.

This health assessment assumed that migrant farm workers and their families live year round at farm worker camps. While this assumption is likely overprotective, information gathered from the community by DOH suggests that some families do stay at the camps year round. In addition, many workers and their families move onto other camps where further exposure to pesticides in soil and indoor dust is possible. Health issues specific to migrant camp workers are addressed on page 20 in the Public Health Implications section of this document.

How am I being exposed?

29. Is bathing harmful to me or my family?

As discussed in the Public Health Implications section on page 12, inhalation of pesticides during bathing and showering is estimated to contribute about half of the total exposure. Dermal absorption is estimated to be minimal but does contribute to the overall dose. The only exposure route of concern for nitrate is ingestion.

30. Are these pesticides in my clothing/laundry?

No. Exposure to pesticides in clothing as a result of washing with contaminated water is not a pathway of concern. These pesticides will either volatilize or remain in the water. Clothes washing could contribute to the overall inhaled dose but the major exposure from this route is estimated to be from showering/bathing.

31. Will irrigation with pesticide contaminated water leave residue on the crops? Will cooking with this water contaminate vegetables?

No. These pesticides will either volatilize from irrigation water or move back into groundwater. Cooking with water contaminated with these pesticides is expected to result in nearly complete loss to air. These pesticides can be inhaled from indoor air after water use such as cooking but this dose is not expected to be significant when compared with the inhaled dose received from showering/bathing.

32. Can you be exposed from pressurized, low-flow toilets?

There may be some volatilization of pesticides from toilets during flushing and from standing water. This potential source of inhalation exposure has not been quantified but is expected to be minimal compared to the estimated dose inhaled during a shower.

33. Can these pesticides accumulate in dairy cows?

These pesticides are not expected to accumulate in plants or animals.

34. Can contaminants in water affect garden plants?

The pesticides found in north Whatcom County groundwater will not damage garden plants. These pesticides do not accumulate in plants and will tend to volatilize during watering. Nitrate is the primary component of fertilizer and will either enhance or do nothing to your plants.

35. Why were vapors not addressed previously?

It is not clear why the potential for inhalation was not addressed earlier. Regardless of the reason, it is clear now and has been for several years that inhalation of volatile chemicals in drinking water is an exposure route of concern.

36. What is the exposure from washing dishes?

The pesticides of concern in area groundwater can volatilize during normal household water uses such as washing dishes. Therefore, pesticides could be inhaled and absorbed through the skin during this activity. While dermal absorption is not considered to be significant for this activity, it is not clear what the inhaled dose might be. Most of the available literature considers inhalation exposure during showering to be the largest percentage of the overall inhaled dose. Nitrate exposure via the inhalation and dermal routes is not of concern.

Miscellaneous

37. What is the cause of blue staining in my bathtub, sinks and water lines?

This is likely the result of soft water (low pH) running through copper pipes. The copper can leach from the pipes as copper chloride or copper sulfate which are both noted for their blue-green color.

38. Is the Nooksack River contaminated? The river should be tested.

The Nooksack River has been tested indirectly by the Cities of Lynden and Ferndale who draw their water supplies from the river. None of the pesticides of concern in area groundwater have ever been detected in either of these municipal supplies.

In addition, EPA sampled surface water along Bertrand Creek in September 1998 and found no pesticides. Contaminated water is expected to discharge to the Nooksack and other tributaries. However, pesticide levels in the river are expected to remain below a level of human health concern due the relatively low levels of these pesticides in groundwater along with the dilution effect of the river.

39. In which direction is groundwater moving? How does groundwater move over time?

In the area surrounding the City of Lynden, groundwater is generally moving at 20-300 feet/year in the direction of the Nooksack River and its tributaries. Seasonal variation does occur with respect to groundwater flow and height of the aquifer (i.e., water table).

40. Why are homes allowed to be built, bought and sold?

DOH does not regulate the sale and purchase of homes regardless of the presence of contamination on the property. You should contact local permitting authorities for the County or a real estate agent regarding the requirements relative to disclosure of environmental contamination during a real estate transaction.

41. More information should be supplied to the community.

WCHHS, DOH, Ecology and EPA have supplied several fact sheets to the community. All of these agencies strive to keep the public informed about the environmental issues affecting residents in the area. Please feel free to call Robert Duff (DOH) toll-free at 1-877-485-7316 or 360-236-3371 if you have any further questions or concerns about the groundwater contamination in north Whatcom County.

42. If my well pumped out large amounts of water would contaminant levels go down?

Probably not and, in fact, they could go up. The main difficulty in assessing the groundwater contamination in north Whatcom County is the fact that a source has not been identified. It appears that the pesticides in groundwater are the result of past use of soil fumigants in several areas. If your well is at the leading edge of a contaminant plume, then increased pumping could draw higher levels into your well. Natural degradation of these pesticides will remove them from the groundwater but this process can take many years. Nitrate levels in your well may change seasonally but will persist if the source persists. The likely source in an agricultural area like north Whatcom County is manure and other fertilizer but septic tanks are also a common source.

43. How can contaminants be removed from a well if they continue to flow in?

Natural degradation will slowly remove the pesticides found in north Whatcom County groundwater. Realistically, there is nothing you can do to prevent contaminants from entering a well if it is drawing water from a contamination zone. However, there are treatment systems that can remove nitrate and pesticides from your well before the water enters your house or at the tap. Different contaminants require different treatment systems that can be costly to maintain. DOH recommends that you evaluate all your options prior to selecting a treatment system. You can contact WCHHS at 360-676-6724 for more information on treatment systems.

Ecology is currently providing bottled water and carbon filtration units that fit on shower heads for those home with EDB or 1,2-DCP above the MCL. In addition, an assessment of various long-term solutions is underway.

44. What are the pesticide reporting requirements for growers?

Pesticide applicators are required to keep records of what they apply and make them available upon request to the Washington State Department of Agriculture (WSDA). However, these are not public records. House Bill 2741, which is currently before the State of Washington legislature, calls for a pesticide use tracking system to be established that will make pesticide use information readily available to the public. Appendix E contains information regarding pesticide use on red raspberries (the predominant crop in north Whatcom County).

CONCLUSIONS

1) A public health hazard exists for residents exposed to pesticides found in drinking water wells in the north Whatcom County area. Ingestion of drinking water and inhalation of vapors during showering are the primary routes of exposure. Exposure to these pesticides at levels above respective MCLs can pose a moderate to low increase in cancer risk over many years of exposure. In addition, the presence of EDB or multiple pesticides in drinking water at levels below respective MCLs will also carry some cancer risk. These estimates of cancer risk are based on animal experiments involving doses well in excess of anything experienced by north Whatcom County residents. These pesticides have *not* been shown to cause cancer in humans although studies of human populations are limited.

Non-cancer adverse health effects are not anticipated to result from exposure to the levels of these pesticides found in north Whatcom County groundwater. MCLs for these pesticides appear to be protective against non-cancer endpoints.

2) A public health hazard exists for pregnant women and bottle-fed infants exposed to nitrate in drinking water at levels above the MCL. While this risk appears to be small, current data examining adverse birth outcomes and methemoglobinemia suggest that some risk exists at levels approaching 20 ppm. Further investigation of the health risks associated with nitrate in drinking water is warranted.

3) No apparent public health hazard exists for migrant farm workers exposed to pesticides in drinking water. Only very low levels of 1,2-DCP were detected in two of seven wells during the most recent sampling round while all other pesticides of concern were not detected. Non-cancer health effects are not expected and cancer risk is not considered significant at current levels of 1,2-DCP in these wells. Consistent with other wells in the area, levels of 1,2-DCP appear to be declining in these two migrant camp wells. The past presence of EDB in the Ehlers camp well did represent a low to very low cancer risk for long-term exposure.

4) Nitrate has consistently been detected at or above the MCL in many of the migrant camp wells and therefore, poses a hazard to pregnant women and bottle-fed infants. The additional exposure of migrant farm workers to pesticides in soil and indoor dust is also cause for concern. While these pathways were not quantified in this health assessment, they are a potential source of pesticide exposure.

5) No apparent public health hazard exists for persons exposed to mixtures of pesticides and nitrate in drinking water at or below respective MCLs. A recently published long-term animal study suggests that nitrate present with very low levels of aldicarb and atrazine could have subtle effects on the immune system. While these pesticides are not generally found in north Whatcom County groundwater, this study is important mainly due to the fact that effects were seen at environmentally relevant doses. Interactions between nitrate and pesticides commonly found in groundwater need to be examined more thoroughly in light of these data.

RECOMMENDATIONS

1) Residents using drinking water wells contaminated with pesticides above respective MCLs should take steps to reduce both ingestion and inhalation exposure. In addition, residents using domestic water supplies contaminated with any detectable levels of EDB or multiple pesticides should consider reducing exposure.

- Effective remedial measures include an alternate water source, drinking bottled water, increasing ventilation while showering/bathing, installing a carbon filtration device on shower-heads or installing a point-of-entry water treatment system.

2) Pregnant women and infants should not drink water containing nitrate at or above the MCL of 10 ppm. Other domestic uses of nitrate contaminated water are not considered to be a health hazard.

- Effective remedial measures include an alternate water source, drinking bottled water and installing an appropriate treatment system for your drinking water.

3) Residents using drinking water wells contaminated with nitrate at or above the MCL *and* detectable levels of pesticides should consider steps to reduce both ingestion and inhalation exposure.

- Effective remedial measures include an alternate water source, drinking bottled water, increasing ventilation while showering/bathing, installing a carbon filtration device on shower-heads and installing an appropriate treatment system for your drinking water.

4) Steps should be taken to reduce the potential for combined exposure of migrant farm workers to pesticides and nitrate in drinking water and pesticides in soil and indoor dust.

- Annual sampling and analysis for 1,2-DCP should continue at those migrant camp wells that contain 1,2-DCP until decreasing trends are established. DOH will evaluate results of this testing. Nitrate sampling of these wells should adhere to current state and federal regulations.

- Growers should ensure that their workers observe proper re-entry times when working in fields applied with pesticides. Re-entry time information is provided on the pesticide label.

- Farm workers should take steps to reduce the amount of soil tracked inside the home from pesticide treated fields. Effective measures include removing work

clothes and boots before entering the main living areas of the home and keeping pets outside the home and/or away from pesticide treated fields.

5) Residents living in areas of concern who have not had their wells tested should consider testing for EDB, 1,2-DCP, 1,2,3-TCP, DBCP and nitrate. Areas of concern include Study Areas A and B (see Figure 2) and any other agricultural areas with historical use of soil fumigants.

- WCHHS has information on past and present agricultural land use as well as information on certified laboratories that test for pesticides and nitrate. WCHHS can be contacted at 360-676-6724. Ecology is currently evaluating groundwater contamination in the north Whatcom County area and may conduct further testing of private drinking wells.

6) DOH and ATSDR should pursue opportunities to examine the relationship between exposure to nitrate in drinking water and adverse health effects, specifically, methemoglobinemia in infants and adverse birth outcomes.

7) DOH and ATSDR should pursue opportunities to study the potential for adverse health effects, specifically on the immune system, from exposure to mixtures of nitrate and pesticides in drinking water.

8) WCHHS should continue to provide input to county and local planning departments to ensure that no new drinking water wells are located in contaminated areas. In addition, WCHHS should take an active role in developing strategies to reduce the potential for further contamination of the Sumas-Blaine aquifer.

- The water quality database compiled by WCHHS for the north Whatcom County area should provide an excellent resource with which to make informed planning decisions with regard to reducing the potential for exposure to contaminants in groundwater.

PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan (PHAP) for the Whatcom County Groundwater site is outlined below. The purpose of the PHAP is to ensure that this health assessment not only identifies public health hazards, but also provides a plan of action designed to prevent or mitigate adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR and DOH to ensure that these actions are taken.

Actions Taken:

The Washington State Department of Ecology (Ecology) is currently providing bottled water and carbon filtration devices to homes with contamination at or above the MCL.

The Washington State Department of Health (DOH) has evaluated potential links between elevated leukemia rates in north Whatcom County and pesticides in drinking water. The results of this evaluation were presented at a public meeting on July 19, 1999.

The Environmental Protection Agency (EPA) conducted a Site Investigation of the north Whatcom County area in response to a petition expressing concern over possible source areas of pesticide groundwater contamination.

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted an exposure investigation to determine the potential for inhalation of pesticides that volatilize from water during a shower.

DOH conducted state-wide testing of drinking water wells serving migrant farm worker facilities in the summer and fall of 1999.

DOH held an open house on March 30, 1999, to hear community health concerns related to groundwater contamination in the north Whatcom County area.

A joint public meeting organized by Ecology and DOH was held on October 20, 1999, to present the findings of this health assessment and the evaluation of remedial alternatives for contaminated wells.

Several fact sheets and consultations have been distributed to affected residents by Whatcom County Health and Human Services (WCHHS) and other agencies, providing information relative to drinking water contaminants, potential health effects and mitigative actions.

Actions Planned:

Ecology will propose long-term solutions for domestic water contaminated with EDB and 1,2-DCP for residences in the Bertrand Creek study area based on an evaluation of available

options, including alternative sources, filtration and bottled water. A companion decision-making tool is being developed that may assist in assessing cost effective solutions for other similar contaminants.

ATSDR is considering a pilot study using mailed questionnaires or medical record review along with existing water supply sampling data to evaluate the risk of spontaneous abortion relative to exposure to nitrates in drinking water. This pilot would determine the feasibility of a retrospective approach to investigating this health risk, and of conducting a larger case-control study.

DOH is evaluating the feasibility of a targeted surveillance project that will help determine the incidence of methemoglobinemia in infants and its relationship to nitrate levels in drinking water. The project would require collaboration with local health departments. The WCHHS has agreed to assist DOH in such efforts.

WCHHS will continue to work with county and local planning departments to ensure that no new residential drinking water wells are located in areas of groundwater contamination.

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APPENDIX A: Figures

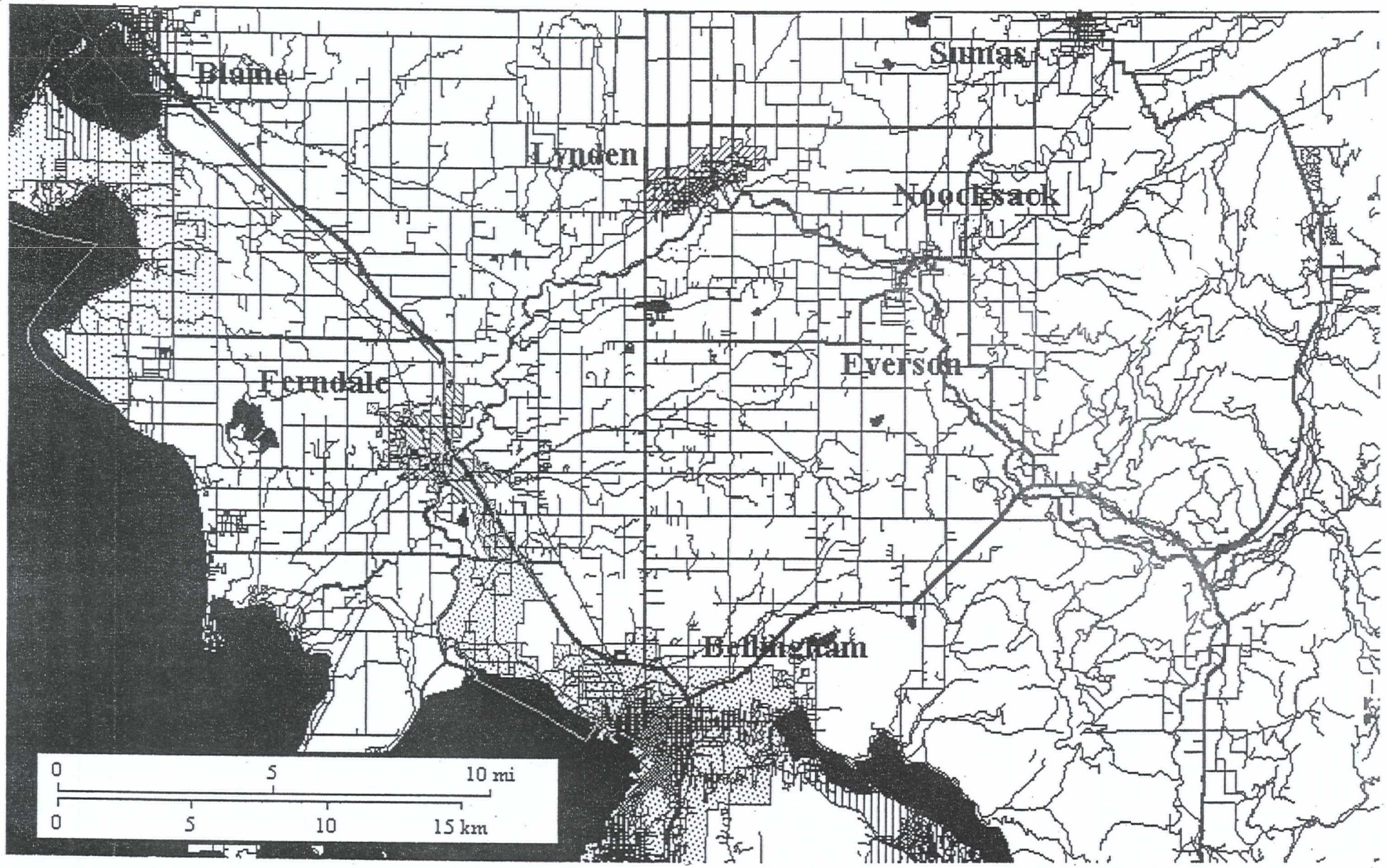

Figure 1. North Central Whatcom County, Washington (adapted from Ref. 4).

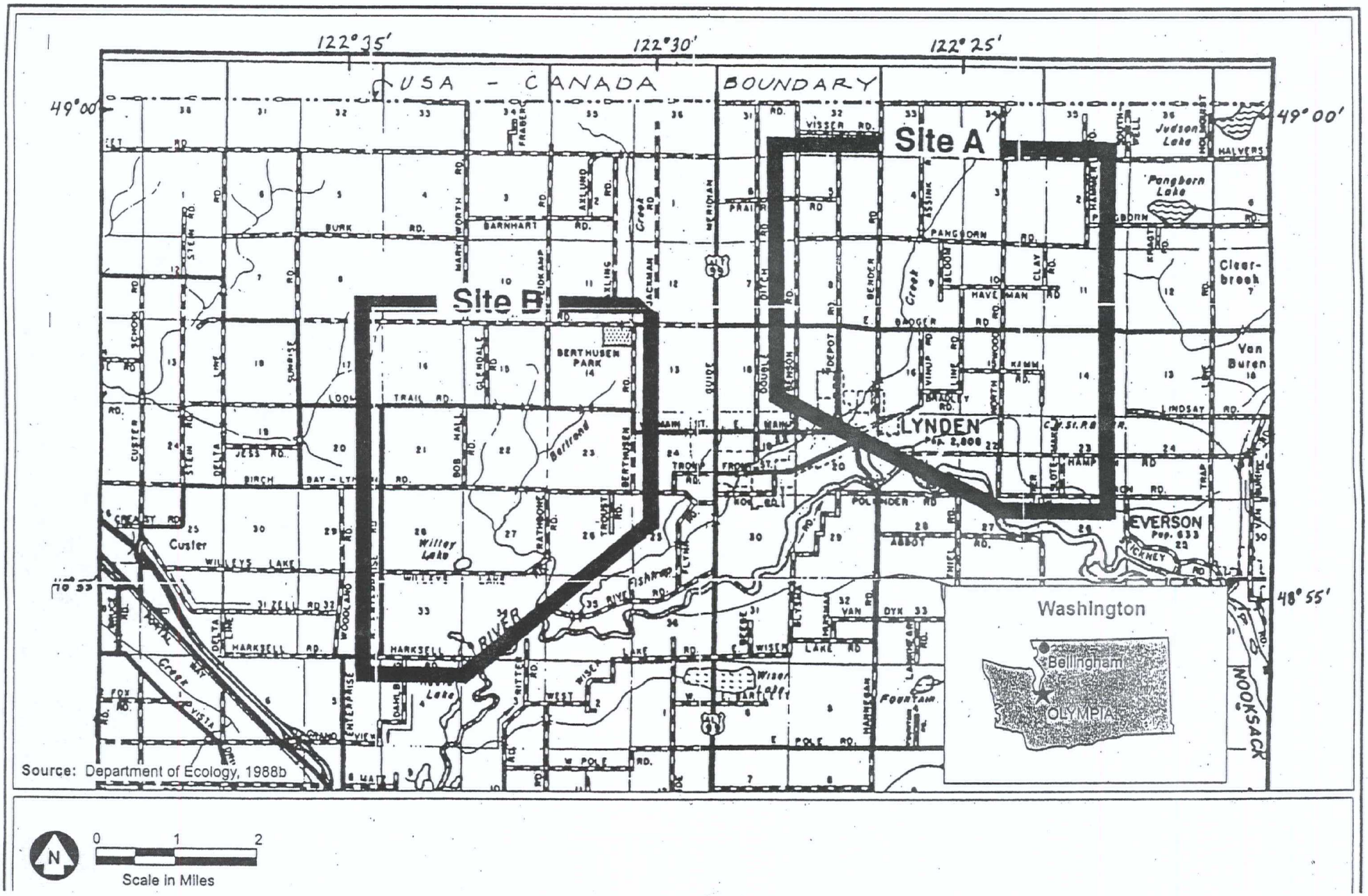

Figure 2. Study Area A (Meadowdale) and Study Area B (Bertrand Creek) (adapted from Ref. 14).

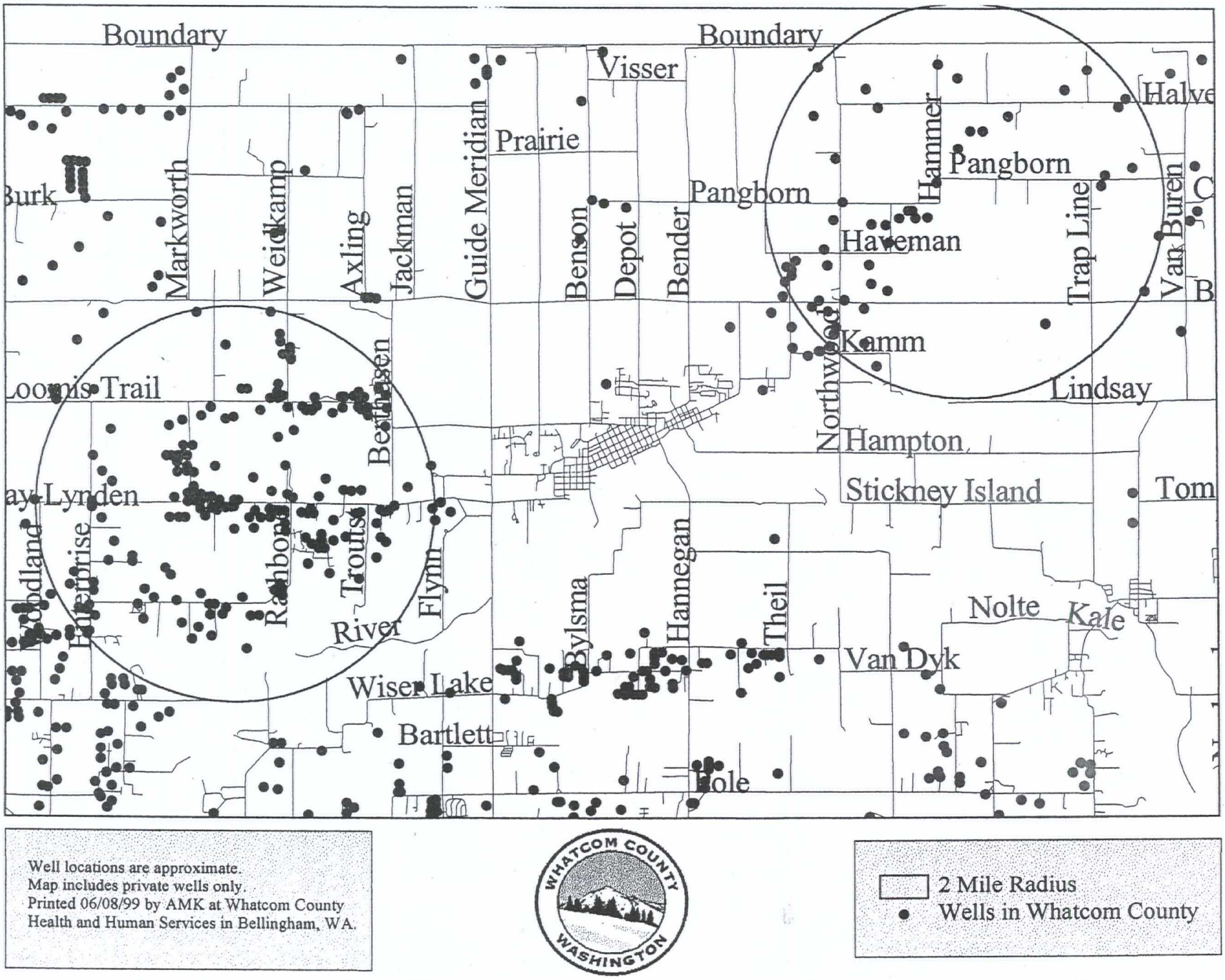

Figure 3. Approximate Boundaries and Well Locations of Study Area A (Meadowdale) and Study Area B (Bertrand Creek) within a 2-mile Radius (provided by WCHHS).

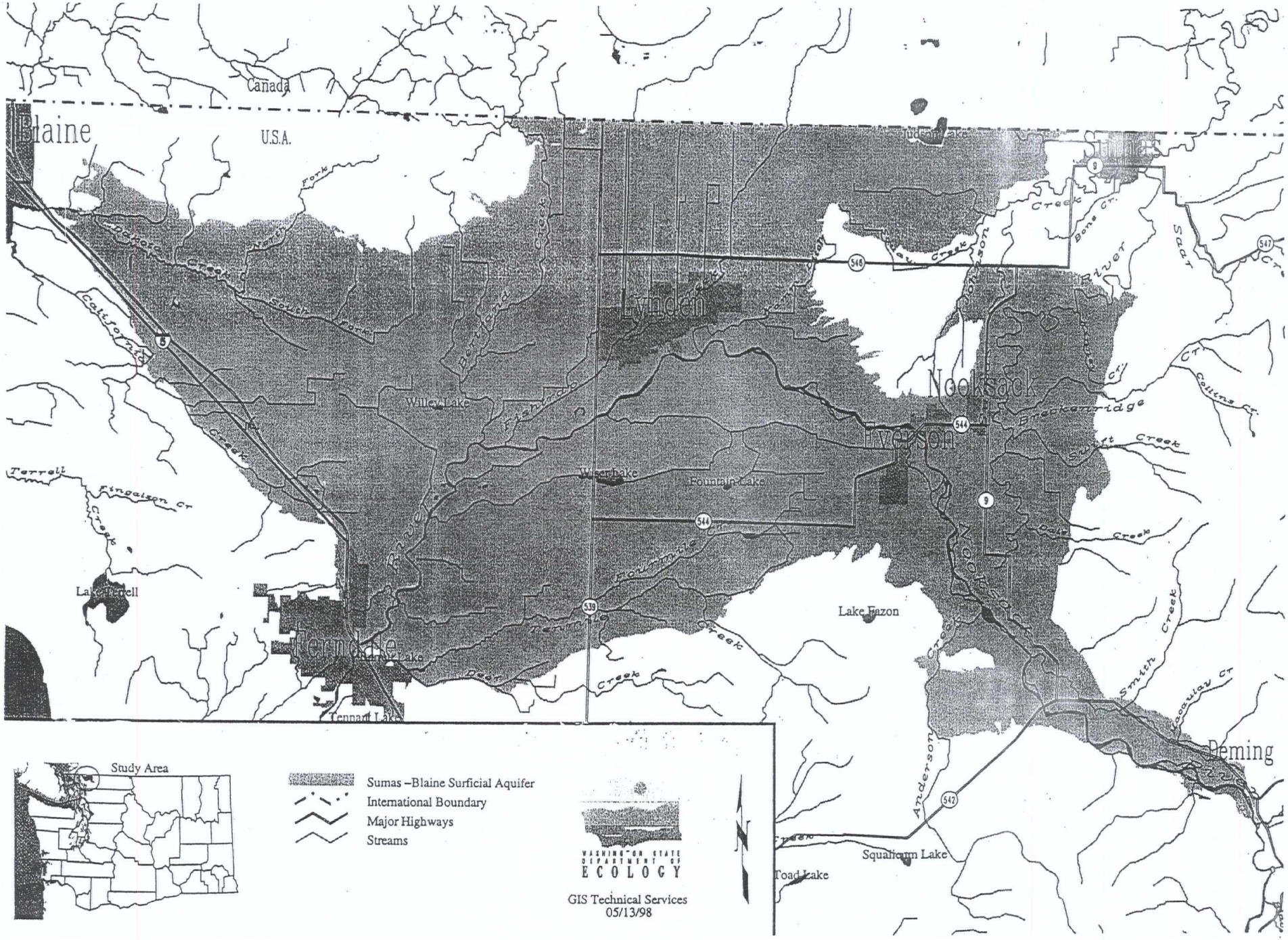

Figure 4. Boundaries of the Sumas-Blaine Aquifer (adapted from Ref. 9).

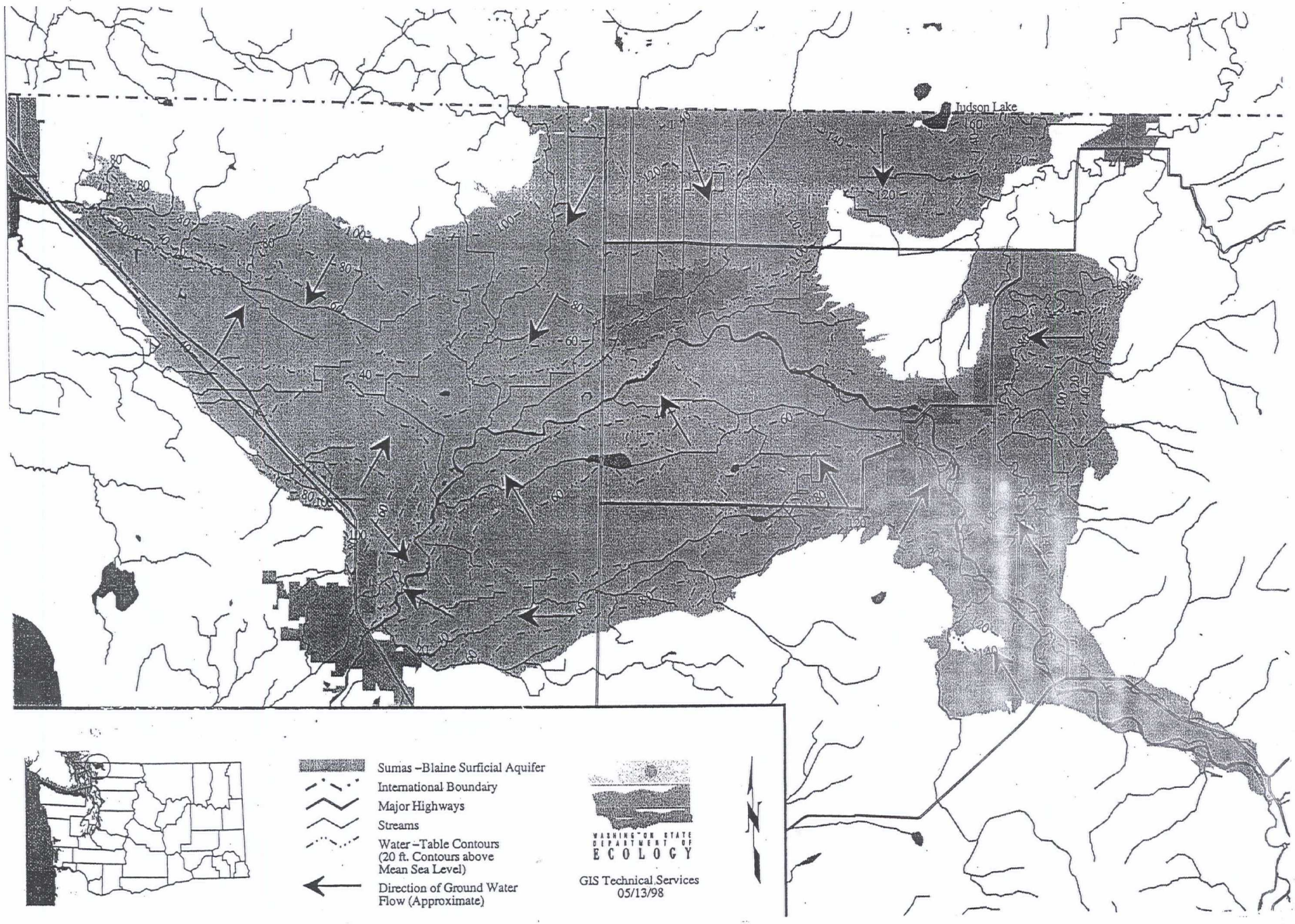

Figure 5. Direction of Groundwater Flow in the Sumas-Blaine Aquifer (adapted from Ref. 9).

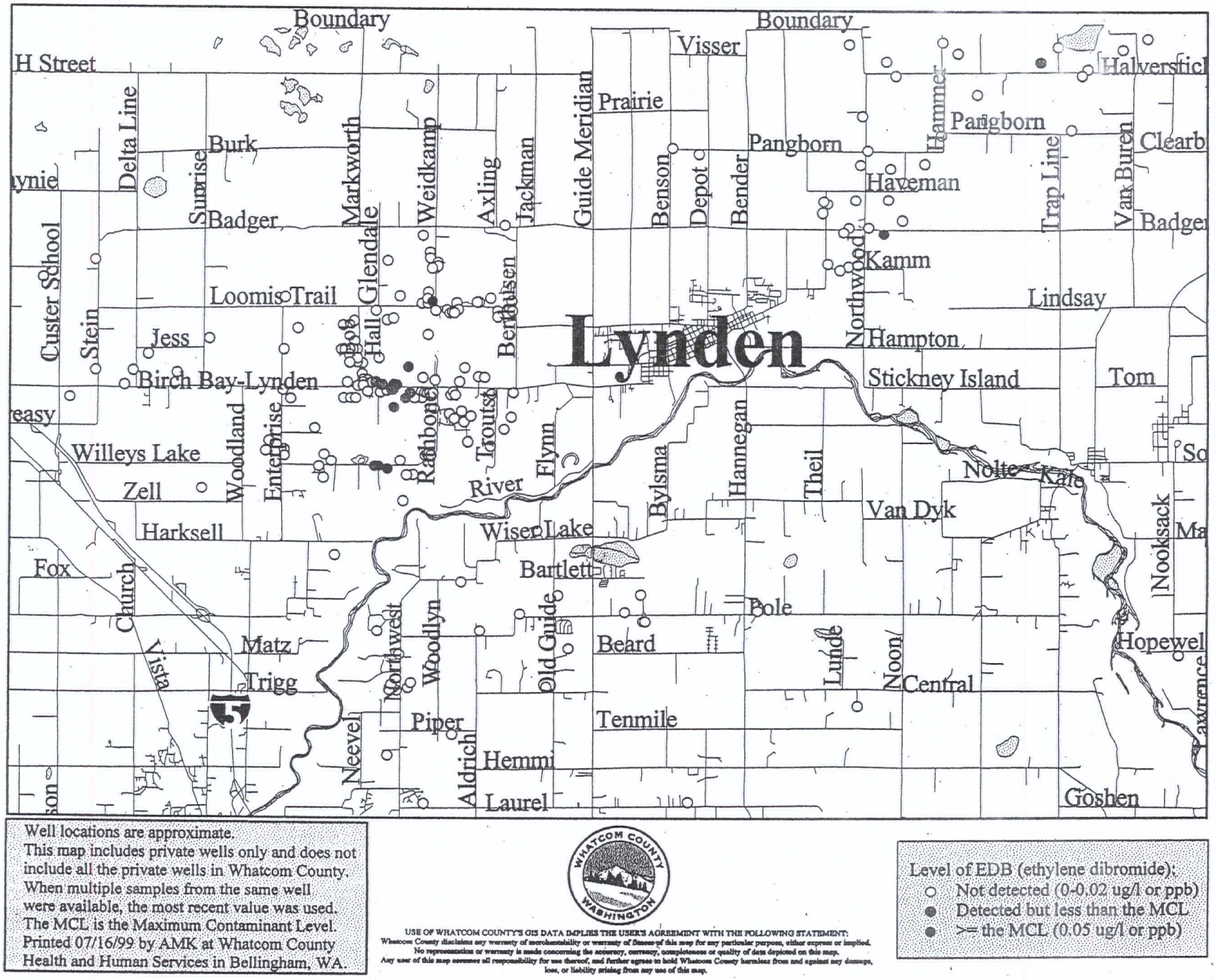

Figure 6. Results of Whatcom County Well Testing for EDB from 1991-1999 (provided by WCHHS).

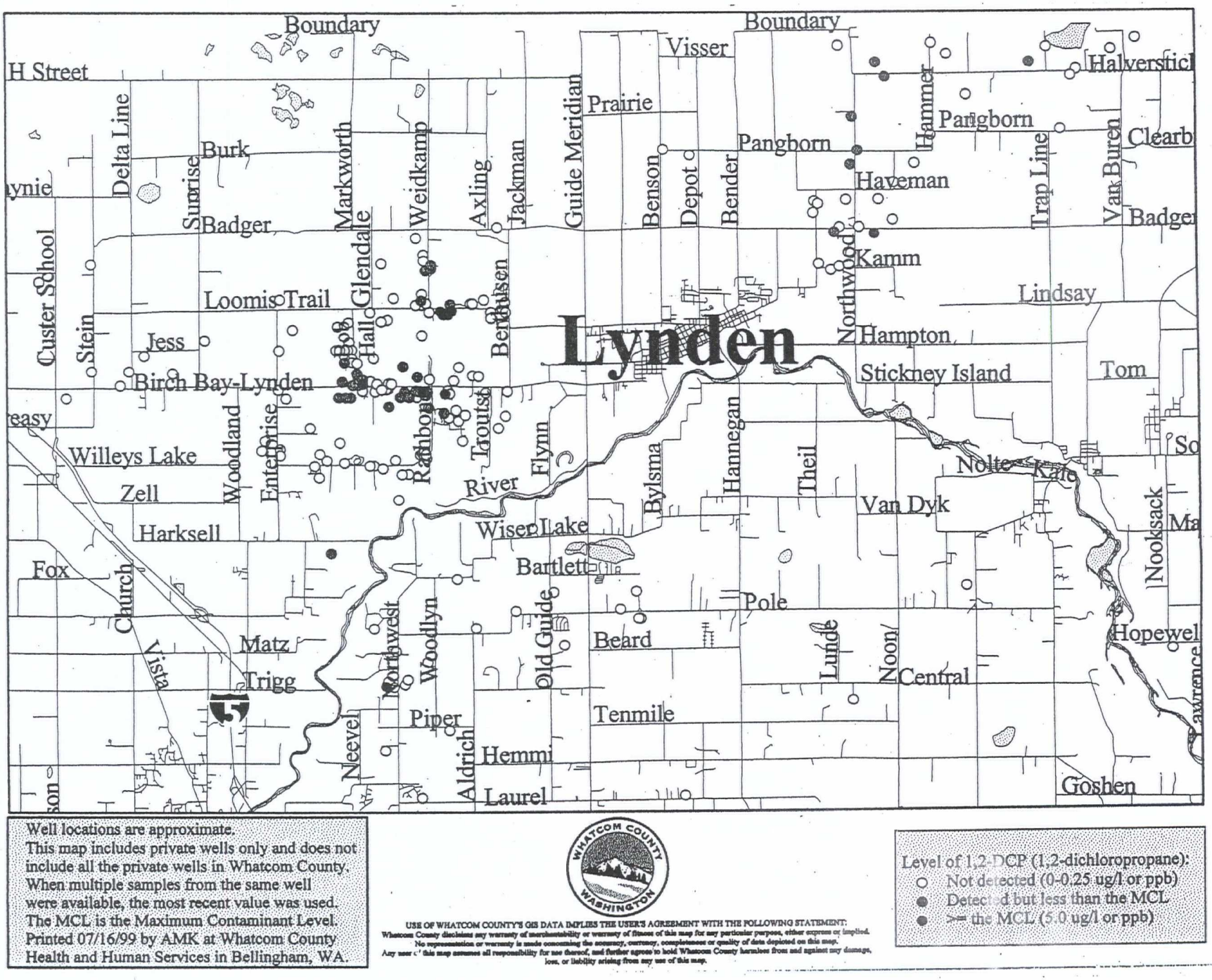

Figure 7. Results of Whatcom County Well Testing for 1,2-DCP from 1991-1999 (provided by WCHHS).

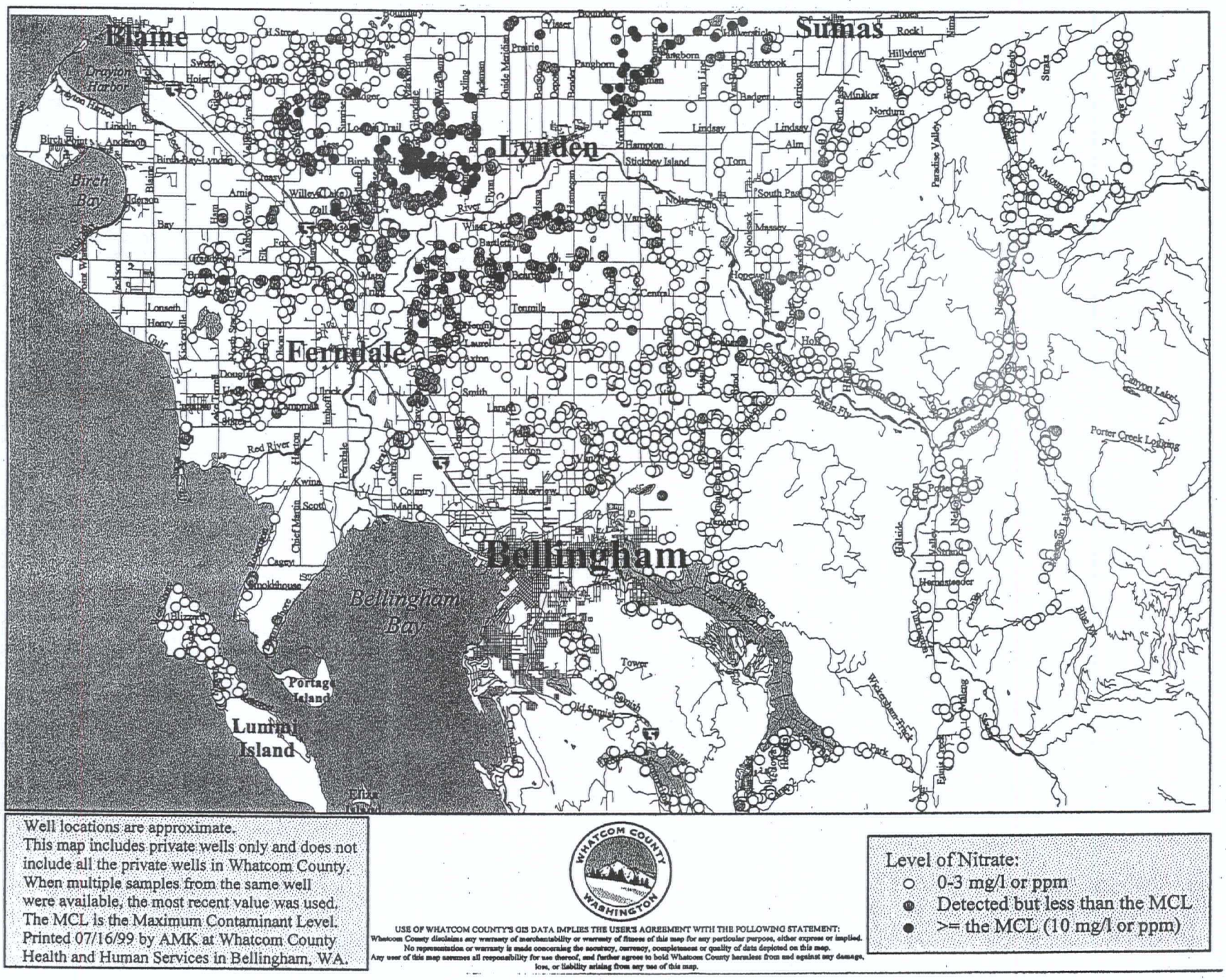

Figure 8. Results of Whatcom County Well Testing for Nitrate from 1991-1999 (provided by WCHHS).

APPENDIX B: Exposure Dose Calculations

This appendix provides the exposure assumptions and calculated doses used to estimate health risks associated with exposure to contaminants of concern in drinking water. The dose estimates for each of these pathways are discussed under the Pathways Analysis/Public Health Implications section of the document. The reader should be aware that maximum concentrations are used to calculate these doses. This represents a worst-case scenario that may overestimate actual exposure. Non-cancer dose calculations assumed a five-year exposure of a child from birth through 5 years of age. Cancer dose calculations assumed a 30-year exposure of a child growing to adulthood.

Maximum air concentrations reached during a 20-minute shower were estimated using a mathematical model.[c] Use of maximum concentrations will likely over estimate total shower inhalation exposure since maximum levels will not be present during the entire shower. This conservative approach was used to account for other sources of exposure such as clothes and dish washing that were not considered in the dose estimate. Dermal absorption during a 20-minute shower was estimated using EPA guidance.[d]

Ingestion

Non-cancer

$$ID_{0\text{-}5} = \frac{C \times IR_{0\text{-}5} \times CF \times EF_{0\text{-}5} \times ED}{BW_{0\text{-}5} \times AT_{\text{non-cancer}}}$$

Cancer

$$\sum (ID_{0\text{-}5,6\text{-}15,16\text{-}30} \times CSF)$$

$$ID_{0\text{-}5} = \frac{C \times IR_{0\text{-}5} \times CF \times EF_{0\text{-}5} \times ED}{BW_{0\text{-}5} \times AT_{\text{cancer}}}$$

$$ID_{6\text{-}15} = \frac{C \times IR_{6\text{-}15} \times CF \times EF_{6\text{-}15} \times ED}{BW_{6\text{-}15} \times AT_{\text{cancer}}}$$

$$ID_{16\text{-}30} = \frac{C \times IR_{16\text{-}30} \times CF \times EF_{16\text{-}30} \times ED}{BW_{16\text{-}30} \times AT_{\text{cancer}}}$$

Inhalation Exposure Assumptions

ID	= Inhaled Dose (mg/kg-day)
C	= Concentration in air (mg/m^3)
$Inh_{0\text{-}5}$	= Inhalation Rate = 0.11 m^3/day
$Inh_{6\text{-}15}$	= Inhalation Rate = 0.19 m^3/day
$Inh_{16\text{-}30}$	= Inhalation Rate = 0.21 m^3/day
CF	= Conversion Factor = 0.001 ppm/ppb
EF	= Exposure Frequency = 350 days/year
$ED_{0\text{-}6}$	= Exposure Duration = 5 years
$ED_{6\text{-}15}$	= Exposure Duration = 10 years
$ED_{16\text{-}30}$	= Exposure Duration = 15 years
$BW_{0\text{-}6}$	= Body Weight = 15.3 kg
$BW_{6\text{-}15}$	= Body Weight = 41.1 kg
$BW_{16\text{-}30}$	= Body Weight = 71.8 kg
$AT_{\text{non-cancer}}$	= Averaging Time = 1825 days
AT_{cancer}	= Averaging Time = 25550 days

[c] Foster SA, and Chrostowski PC. Inhalation exposures to volatile organic contaminants in the shower. Presentation at the 80th Annual Meeting of the Association Dedicated to Air Pollution Control and Hazardous Waste Management (ALCA). New York, NY. June 1987.

[d] U.S. Environmental Protection Agency. Dermal Exposure Assessment: Principles and Applications. Interim Report. January 1992. EPA/600/8-91/011B.

Inhalation - (Shower)

Non-cancer

$$ID_{0-5} = \frac{C \times Inh_{0-5} \times EF_{0-5} \times ED}{BW_{0-5} \times AT_{non\text{-}cancer}}$$

Cancer

$$\text{Cancer Risk} = \sum (ID_{0-5,6-15,16-30} \times CSF)$$

$$ID_{0-5} = \frac{C \times Inh_{0-5} \times EF_{0-5} \times ED}{BW_{0-5} \times AT_{cancer}}$$

$$ID_{6-15} = \frac{C \times Inh_{6-15} \times EF_{6-15} \times ED}{BW_{6-15} \times AT_{cancer}}$$

$$ID_{16-30} = \frac{C \times Inh_{16-30} \times EF_{16-30} \times ED}{BW_{16-30} \times AT_{cancer}}$$

Ingestion Exposure Assumptions

ID	=	Ingested Dose (mg/kg-day)
C	=	Concentration in drinking water (ppb or ug/l)
IR_{0-5}	=	Ingestion Rate = 0.87 l/day
IR_{6-15}	=	Ingestion Rate = 0.97 l/day
IR_{16-30}	=	Ingestion Rate = 1.4 l/day
CF	=	Conversion Factor = 0.001 ppm/ppb
EF	=	Exposure Frequency = 350 days/year
ED_{0-5}	=	Exposure Duration = 5 years
ED_{6-15}	=	Exposure Duration = 10 years
ED_{16-30}	=	Exposure Duration = 15 years
BW_{0-5}	=	Body Weight = 15.3 kg
BW_{6-15}	=	Body Weight = 41.1 kg
BW_{16-30}	=	Body Weight = 71.8 kg
$AT_{non\text{-}cancer}$	=	Averaging Time = 1825 days
AT_{cancer}	=	Averaging Time = 25550 days

Dermal Absorption - (Shower)

Non-cancer

$$DAD_{0-5} = \frac{DA_{event} \times SA \times EF_{0-5} \times ED}{BW_{0-5} \times AT_{non\text{-}cancer}}$$

Cancer

$$\text{Cancer Risk} = \sum (ID_{0-5,6-15,16-30} \times CSF)$$

$$DAD_{0-5} = \frac{DA_{event} \times SA_{0-5} \times EF_{0-5} \times ED}{BW_{0-5} \times AT_{cancer}}$$

$$DAD_{6-15} = \frac{DA_{event} \times SA_{6-15} \times EF_{6-15} \times ED}{BW_{6-15} \times AT_{cancer}}$$

$$DAD_{16-30} = \frac{DA_{event} \times SA_{16-30} \times EF_{16-30} \times ED}{BW_{16-30} \times AT_{cancer}}$$

Dermal Absorption Exposure Assumptions

DAD	=	Dermally absorbed dose (mg/kg-day)
DA_{event}	=	Dermally absorbed dose per event (mg/cm^2)
SA_{0-5}	=	Surface area = 6640 cm^2
SA_{6-15}	=	Surface area = 11800 cm^2
SA_{16-30}	=	Surface area = 20000 cm^2
CF	=	Conversion Factor = 0.001 ppm/ppb
EF	=	Exposure Frequency = 350 days/year
ED_{0-6}	=	Exposure Duration = 5 years
ED_{6-15}	=	Exposure Duration = 10 years
ED_{16-30}	=	Exposure Duration = 15 years
BW_{0-6}	=	Body Weight = 15.3 kg
BW_{6-15}	=	Body Weight = 41.1 kg
BW_{16-30}	=	Body Weight = 71.8 kg
$AT_{non\text{-}cancer}$	=	Averaging Time = 1825 days
AT_{cancer}	=	Averaging Time = 25550 days

Table 4. Non-cancer Dose Calculations

Receptor Population	Media	Contaminant	Concentration (ppb)	Exposure Route	Estimated Dose (mg/kg-day)			MRL/RfD (mg/kg-day)	Hazard Index[a]
					Ingestion	Inhalation	Dermal		
Young Child (0-5 years)	Drinking water	EDB	6.1	Ingestion Inhalation Dermal	3.3E-04	2.9E-04	1.1E-05	NA	NA
		1,2-DCP	28.4		1.5E-03	1.1E-03	1.1E-04	9.0E-02	0.03
		DBCP	0.3		1.6E-05	3.5E-06	1.1E-06	2.0E-03	0.01
		1,2,3-TCP	2.4		1.3E-04	5.3E-05	9.1E-06	6.0E-03	0.03
Infant	Formula (drinking water)	Nitrate	56	Ingestion	8.6E+00	NA	NA	1.6	5
		Nitrate	10 (MCL)		1.5E+00	NA	NA	1.6	1

a = Hazard index is the total estimated dose divided by the RfD or MRL.

Table 5. Cancer Dose Calculations

Receptor Population	Media	Contaminant	Maximum Concentration (ppb)	Exposure Route	Cancer Slope Factor ($mg/kg\text{-}day^{-1}$)		Cancer Risk			EPA Cancer Class
					Oral	Inhalation	Ingestion	Inhalation	Dermal[a]	
Child ⇨ Adult (30 years)	Drinking water	EDB	6.1	Ingestion Inhalation Dermal	8.5E+01	7.6E-01	5.8E-03	5.3E-05	2.8E-04	B2
			0.05 (MCL)				4.7E-05	4.4E-07	2.3E-06	
		1,2-DCP	28.4	Ingestion Inhalation Dermal	6.8E-02	6.3E-02	2.2E-05	1.7E-05	2.2E-06	NA
			5 (MCL)				3.8E-06	2.9E-06	3.9E-07	
		DBCP	0.3	Ingestion Inhalation Dermal	1.4E+00	2.4E-03	4.7E-06	2.0E-09	4.8E-07	NA
			0.2 (MCL)				3.1E-06	1.4E-09	3.2E-07	
		1,2,3-TCP	2.4	Ingestion Inhalation Dermal	7.0E+00	NA	1.9E-04	NA	1.9E-05	NA
			40 (LTHA)				3.1E-03	NA	3.2E-04	

a = Dermal cancer risk calculated using the oral cancer slope factor.

APPENDIX C: ATSDR Conclusion Categories

CATEGORY A : URGENT PUBLIC HEALTH HAZARD

This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.

This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.

Criteria:

Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards, such as open mine shafts, poorly stored or maintained flammable/explosive substances, or medical devices which, upon rupture, could release radioactive materials.

**** Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data.***

ATSDR Actions:

ATSDR will expeditiously issue a health advisory that includes recommendations to mitigate the health risks posed by the site. The recommendations issued in the health advisory and/or health assessment should be consistent with the degree of hazard and temporal concerns posed by exposures to hazardous substances at the site.

Based on the degree of hazard posed by the site and the presence of sufficiently defined current, past, or future completed exposure pathways, one or more of the following public health actions can be recommended:

- biologic indicators of exposure study
- biomedical testing
- case study
- disease and symptom prevalence study
- community health investigations
- registries
- site-specific surveillance
- voluntary residents tracking system
- cluster investigation
- health statistics review
- health professional education
- community health education
- substance-specific applied research

CATEGORY B: PUBLIC HEALTH HAZARD

This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.

This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.

Criteria:

Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical hazards, such as open mine shafts, poorly stored or maintained flammable/ explosive substances, or medical devices which, upon rupture, could release radioactive materials.

****Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data.***

ATSDR Actions:

ATSDR will make recommendations in the health assessment to mitigate the health risks posed by the site. The recommendations issued in the health assessment should be consistent with the degree of hazard and temporal concerns posed by exposures to hazardous substances at the site. Actions on the recommendations may have occurred before the actual completion of the public health assessment.

Based on the degree of hazard posed by the site and the presence of sufficiently defined current, past, or future completed exposure pathways, one or more of the following public health actions can be recommended:

- biologic indicators of exposure study
- biomedical testing
- case study
- disease and symptom prevalence study
- community health investigations
- registries
- site-specific surveillance
- voluntary residents tracking system
- cluster investigation
- health statistics review
- health professional education
- community health education
- substance-specific applied research

CATEGORY C: INDETERMINATE PUBLIC HEALTH HAZARD

This category is used for sites when a professional judgement on the level of health hazard cannot be made because information critical to such a decision is lacking.

Criteria:

This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels. The health assessor must determine, using professional judgement, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.

ATSDR Actions:

ATSDR will make recommendations in the health assessment to identify the data or information needed to adequately assess the public health risks posed by the site.

Public health actions recommended in this category will depend on the hazard potential of the site, specifically as it relates to the potential for human exposure of public health concern. Actions on the recommendations may have occurred before the actual completion of the public health assessment.

If the potential for exposure is high, initial health actions aimed at determining the population with the greatest risk of exposure can be recommended. Such health actions include:

- community health investigation
- health statistics review
- cluster investigation
- symptom and disease prevalence study

If the population of concern can be determined through these or other actions, any of the remaining follow-up health activities listed under categories A and B may be recommended.

In addition, if data become available suggesting that human exposure to hazardous substances at levels of public health concern is occurring or has occurred in the past, ATSDR will reevaluate the need for any follow-up.

CATEGORY D: NO APPARENT PUBLIC HEALTH HAZARD

This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.

This determination represents a professional judgement based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete, in some cases additional data may be required to confirm or further support the decision made.

Criteria:

Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.

****Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data; monitoring and management plans.***

ATSDR Actions:

If appropriate, ATSDR will make recommendations for monitoring or other removal and/or remedial actions needed to ensure that humans are not exposed to significant concentrations of hazardous substances in the future. Actions on the recommendations may have occurred before the actual completion of the public health assessment.

The following health actions, which may be recommended in this category, are based on information indicating that no human exposure is occurring or has occurred in the past to hazardous substances at levels of public health concern. One or more of the following health actions are recommended for sites in this category:

- community health education
- health professional education
- community health investigation
- voluntary residents tracking system

However, if data become available suggesting that human exposure to hazardous substances at levels of public health concern is occurring, or has occurred in the past, ATSDR will reevaluate the need for any follow-up.

CATEGORY E: NO PUBLIC HEALTH HAZARD

This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.

Criteria:

Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future.

ATSDR Actions:

No public health actions are recommended at this time because no human exposure is occurring, has occurred in the past, or is likely to occur in the future that may be of public health concern.

APPENDIX D: Response to Public Comments

1. In many places in the document phrases such as "no evidence exists" are used to describe potential health threats. This may be technically correct, but we believe that it would be clearer and more accurate to say something such as "little scientific study has been conducted, and currently no evidence exists" in most of these places.

Changes have been made to address this concern. Suggested language will be used or current phrases will be qualified with an indication as to the amount of negative studies that are available.

2. When we met with representatives from ATSDR we passed along a question from a past resident of Mallard's Landing regarding any possible link between area contaminants and Idiopathic Thrombocytopenic Puppura. At the same meeting the Whatcom County Health Officer acknowledged that he knew of a number of cases of Idiopathic Thrombocytopenic Puppura, and that that number seemed suspiciously high to him. Please address this question.

This health concern was not communicated to DOH. No sampling data were located for the former well at Mallard's Landing. According to DOH public drinking water records, this water system has been inactive since August 1979. Century Water Association currently supplies drinking water to Mallard's Landing. This source is listed as being active since February 1980. Periodic testing of this water supply since 1992 has not detected any of the pesticides associated with groundwater contamination in the area. However, no data were located for this system prior to 1992. For more information on the drinking water supply that served residences at Mallard's Landing please contact the WCHHS at 360-676-6724.

The PHA evaluated exposure and the potential for adverse health effects. Evaluating the relationship between an environmental exposure and a specific health condition requires an epidemiologic investigation that examines the potential relationship between occurrence of a health effect and an exposure. Such an investigation does not appear warranted based on the lack of contamination in the well serving Mallard's Landing.

The condition called idiopathic thrombocytopenic purpurea is characterized by a reduction in blood platelets due to the presence of a substance that agglutinates platelets.[e] By definition, the cause of this condition is unknown. In general, it is important to consult a physician when dealing with a specific health condition. DOH can supply your physician with information relative to the exposure and contaminants in question. In addition, there are physicians located throughout the state who specialize in environmental health. ATSDR supports one such group of physicians, the University of Washington's Occupational and Environmental Medicine Program located at Harborview Medical Center. For more information about physicians who specialize in

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[e] Thomas CL. Taber's Cyclopedic Medical Dictionary. 1985. 15th Edition. Philadelphia: F.A. Davis Company:

environmental health in your area, please contact Sandi Shaw (DOH) toll-free at 1-877-485-7316 or directly at 360-236-3179.

3. The recent EPA investigation found fairly high levels of 1,3 DCP in groundwater samples. Our research has found that studies of 1,3 DCP show it to be a more potent carcinogen than 1,2 DCP. Why is contamination of groundwater by 1,3 DCP not mentioned in the entire assessment?

Analysis of groundwater samples taken by EPA during August and September 1998 detected 1,3 dichloropropane in seven groundwater samples at a maximum of 2.95 ppb.[f] Two of these detections came from private drinking water wells on Birch Bay-Lynden Road while the remaining detections came from monitoring probes. Analysis of groundwater samples taken by Ecology during June, September and October 1998 detected 1,3-dichloropropane in 4 samples at a maximum of 0.14 ppb.[g] 1,3-dichloropropane is produced only for use as an intermediate in the manufacture of other chemicals. Detections of 1,3-dichloropropane in groundwater may be the result of its presence as a contaminant in pesticide mixtures containing 1,3-dichloropropene as the active ingredient. No data on cancer potency were located for 1,3-dichloropropane and no RfDs or MRLs exist for this chemical. Due to its infrequent detection at very low levels, 1,3-dichloropropane was not selected as a contaminant of concern.

The chemical 1,3-dichloropropene is currently used as a soil fumigant but was not detected in any samples during the 1998 EPA and Ecology site investigations. Its use on raspberries is restricted to fumigation of soil prior to replanting. The California Environmental Protection Agency lists both 1,2-DCP and 1,3-dichloropropene in their report entitled, "Criteria for Carcinogens", released by the Standards and Criteria Work Group. This list of cancer potency factors shows that 1,3-dichloropropene has an oral cancer potency factor about three times higher than 1,2-DCP while the inhalation potencies are approximately equal. U.S. EPA currently lists 1,3-dichloropropene as a Group B2 probable human carcinogen but withdrew its cancer potency factor in October 1989 for further review.

4. In general some of the recommendations, (such as "Farm workers should observe proper re-entry times for fields applied with pesticides), may be difficult to control, and puts the onus of responsibility on the farm worker or home owner. This approach seems doomed to failure, and removes the responsibility from the pesticide applicators who are causing the problem. A better recommendation would be "Pesticide applicators should be required to ensure that farm workers observe proper re-entry times."

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[f] Roy F. Weston, Inc. Bertrand Creek Properties: Site Investigation Report, Lynden, Washington. Prepared for the U.S. Environmental Protection Agency, Region 10. March 1999.

[g] Washington State Department of Ecology. 1998 Site Investigation Bertrand Creek & Meadowdale Areas, Whatcom County, Washington. October 1999. Publication No. 99-601.

The role of ATSDR and DOH with respect to the public health assessment (PHA) process is an advisory one. Neither agency has regulatory authority to enforce these recommendations as that responsibility lies with other agencies (e.g., Ecology, EPA, OSHA). However, DOH does have regulatory authority to enforce drinking water regulations for *public* water supplies.

The recommendations contained within this PHA are designed to reduce or eliminate exposure to hazardous substances that have been determined to pose a health risk. Methods for reducing exposures of concern (risk management) are left to the regulatory agencies. DOH recognizes that some exposures of concern will not trigger a regulatory response. In such cases recommendations are targeted to the exposed population in order to provide them with guidance on how to reduce such exposure. With respect to the recommendation noted, (# 4, page 35), DOH has no information as to whether re-entry times are being observed or not. The recommendation serves to reiterate that following these *existing* guidelines could help reduce general exposure to pesticides. As stated in the recommendation, this information should be supplied by the employer and is also contained on the pesticide label.

5. In recommendation #5 we do not understand the rationale for only including migrant farm workers in the concern regarding combined exposure to "pesticides in soil and dust." Many of the residents in the area have nitrate contaminated wells, and are closely surrounded by agricultural pesticide use as well as the pesticides they may be using on their own yards, homes, and pets. We believe this recommendation needs to be expanded to all area residents, and needs to be backed up with a health action plan item to educate area residents about this exposure path.

It is beyond the scope of this document to address all potential sources of exposure beyond that associated with nitrate and pesticides in groundwater. The PHA addresses the potential for exposure of migrant workers to pesticides in soil and indoor dust because available data indicate that this pathway is of concern. In addition, community health concerns gathered by DOH indicated that this pathway was of concern to workers.

6. A couple of times in the report you state that "The location and boundaries of groundwater contamination plumes have not been established." Recent investigation by the EPA have found level of 1,2 DCP much higher than recorded previously, and identified new potential plumes the boundaries of which are still unknown. We believe that a recommendation and health action plan needs to be added to actively determine the extent of the contamination to ensure public health. This also needs to be accomplished before legitimate analysis of potential alternative water supplies can logically move forward.

The lack of identifiable plume boundaries is indeed of concern and does present the possibility of unidentified exposure to contaminants in groundwater. Recommendation #5 (page 36) is intended to address this issue by encouraging residents to test their wells if they live in areas of concern. DOH has already commented to Ecology regarding the Bertrand Creek site investigation and the need to identify any other plumes that might be present in hte North Whatcom county area.

Ecology is proposing more sampling to address this issue and this fact will be amended to the Public Health Action Plan

7. We are deeply concerned by the Departments inability to obtain pesticide application records. In answer to question #44 you state that "Pesticide applicators are required to keep records of what they apply." Yet in three different places you state that during the year and a half this assessment took you were unable to obtain such records. Please explain who has these records, and why state and federal health officials were unable to obtain them. We believe that a logical recommendation from this inability to obtain records would be to ask for an expansion of the applicators record keeping requirements. We also believe that citizens should also have access to such records so they can determine what is being used in their areas since citizens are required to cover the costs of protecting their health by testing their wells.

The PHA has been updated to reflect information on current pesticide use. The formal PHA process dates back to the initial acceptance by ATSDR of a community petition on November 16, 1998. At this time ATSDR agreed to conduct an exposure investigation and asked DOH to prepare a health consultation and conduct community health education. On March 30, 1999, DOH held a public availability session in Lynden to gather community health concerns. One of the concerns raised was related to current applications of pesticides. DOH pursued this information by contacting a pesticide applicator that serves berry growers in the north Whatcom County area. Unfortunately, no data were exchanged despite a verbal agreement to do so.

Applicators are required to keep files on pesticide application and make them accessible to the Washington State Department of Agriculture (WSDA). However, these are not public records. DOH contacted a local pesticide applicator and several state and federal agencies in order to obtain information concerning current use of pesticides on raspberry fields. Raspberry fields are the predominant crop in the north Whatcom County area. It is clear that there are several pesticides for a raspberry grower to choose from and not all growers will use the same pesticides in the same amounts. In order to make their crop profitable, growers tend to use as little pesticide as possible since the costs of such use can be significant. For example, a soil test for nematodes is often a prerequisite for determining the need for fumigation of a field. The market also dictates pesticide use since growers sending their harvest to juice makers will use less fungicide than those harvesting for produce.

Discussions with WSDA indicated that summary statistics provided by the USDA provide the best information with regard to pesticide usage on raspberry fields in the State of Washington. This information is presented in Appendix E. More complete information is available on the Internet at "http://pestdata.ncsu.edu/cropprofiles/Detail.CFM?FactSheets__RecordID=55". The USDA information provides an excellent overview of recent pesticide use organized by crop and state.

House Bill 2741, which is currently before the state of Washington legislature, calls for a pesticide use tracking system to be established that will make pesticide use information readily available to

the public. Several factors play a role in determining whether a pesticide applied on a field will be a threat to a drinking water well. Among these factors are type of pesticide application (i.e., soil versus foliar), chemical physical properties of the pesticide, amount applied, frequency of application, movement of groundwater, location of drinking water wells and type of aquifer. If you are concerned about pesticides in your well and how to test for them, please contact the WCHHS at 360-676-6724 or DOH toll-free at 1-877-485-7316.

8. Your recommendations do not mention the need for pollution prevention. In a shallow aquifer, such as the one in northern Whatcom County, contamination can only be avoided if farmers, residents, and businesses all reduce the use of potential contaminants, and handle the contaminants they do use correctly. Local government also needs to provide adequate zoning to protect this valuable drinking water source. These ideas should form the foundation of protecting the public health and should be included in your recommendations.

Source reduction of pollutants entering the environment is an important aspect of public health protection. This comment speaks to the need for a reduction in "background" exposure as part of a valid attempt to reduce overall health risk. An additional recommendation directed at the WCHHS will be added regarding their participation in ongoing efforts to reduce the potential for pesticide and nitrate groundwater contamination in the north Whatcom County area..

This recommendation will be made with the understanding that efforts are already underway to achieve this goal. A local ordnance was passed in 1998 restricting the use of manure with respect to where and when it can be applied. In addition, WCHHS is working with local planning boards to prevent the siting of new private drinking water wells in areas of known contamination. WCHHS will continue efforts to implement Integrated Pesticide Management practices as specified in the Abbotsford Sumas International Task Force Agriculture Plan. WCHHS will also be involved in future activities relating to protection of the Sumas-Blaine aquifer that could include designating this aquifer as a Groundwater Management Area.

9. Finally, many of the public health actions already taken, and those yet to come, will take a significant amount of money. Please include an action plan for paying for ongoing programs, so these issues don't fall through the cracks like they did in the 1980s. We do not think that it is fair for taxpayers to continue to subsidize these cleanup costs so chemical companies can continue to pollute and make huge profits. We would like to see a recommendation that the State Attorney General actively seek to recoup costs of alternative water supplies, as well as educational efforts, either cooperatively or through the courts, from the chemical companies that produced the pesticides of concern.

As noted previously, some recommendations are not within the scope of this document. DOH does not have the authority or responsibility to recoup cleanup costs from potentially liable parties. The state of Washington filed suit in 1988 against the Great Lakes Chemical Company to recoup costs associated with investigations of EDB contamination in groundwater. A $575,000

settlement was reached in January 1992 that defined the boundaries of investigation for four sites two of which were located in Whatcom County (Meadowdale and Bertrand Creek).

10. The summary states that "no apparent public health hazard exists for migrant farm workers exposed to pesticides in drinking water." It also states that "no apparent public health hazard exists for persons exposed to mixtures of pesticides and nitrate in drinking water at or below respective MCLs." However, the recent University of Wisconsin study that looked at exposure to mixtures of pesticides and nitrate does show that there are adverse effects. Results of this study should be reflected in the summary statements.

The summary is intended to provide the most important elements of each section of the document. Conclusion are given in the summary along with other clarifying statements. The Conclusions section (page 34) of the PHA provides more detail in support of the each conclusion.

11. In the 'recommendations' section, the draft report states that 'migrant farm workers should take steps to reduce exposure...to pesticides..." Farm workers have no control over the amount and/or type of pesticides used in their work environment and therefore cannot take steps to reduce their exposure in any meaningful way. The burden should not be placed on the farm worker. The recommendation as written is disingenuous; it should instead call for action on the part of employers and regulatory agencies in order to protect farm workers from exposure to dangerous chemicals. These action steps should include pollution prevention and the use of the precautionary principle.

Recommendation #4 emphasizes the need to observe proper re-entry times. Regulations already exist regarding re-entry times and other aspects of pesticide handling by workers. DOH has no evidence that existing regulations are not being observed. The recommendation was made to reiterate the need to follow these regulations. Recommendation #4 will be modified to reflect that the employer is in the only position to ensure that proper re-entry times are observed.

Although some exposure will invariably occur when working with pesticides or in pesticide-treated fields, workers can certainly take steps to limit their exposure. For example, farm workers can reduce the amount of pesticide contaminated soil tracked inside the home. This pathway of exposure is not readily apparent but is easily reduced by removing work clothes prior to entering the home.

12. Further, the Recommendations section states that 'residents using drinking water with nitrate at or above the MCL and detectable levels of pesticides should consider steps to reduce exposure." However, there is no mention of the migrant farm worker camps, many of which had high nitrate levels above the MCL, as well as detections of 1,2-DCP. Dept. of Health should take action to ensure that workers and their families have a safe water supply – levels of nitrate in the range found in migrant camp wells of 16 – 25 ppm are NOT acceptable. All camps except 1 had nitrate levels at or above the MCL.

The issue of nitrate and pesticide exposure of migrant camp workers is addressed in Recommendation #4. However, Recommendation #3 will be modified to include migrant camp workers. There is currently only one migrant camp well that has detectable levels of pesticides (1,2-DCP). Continued sampling of this well for 1,2-DCP is recommended along with nitrate sampling in accordance with current regulations.

13. There is no mention of current pesticide use or 1,3-DCP. Though not as persistent in groundwater, information from California shows that 1,3-DCP has 10 times the carcinogenic potential of 1,2-DCP. Potential health effects from current pesticide applications should be explored in this document.

Please see response to Comment #3.

14. The recommendations on testing for pesticides in migrant camp wells should specify that testing should be done yearly.

The Division of Drinking Water within DOH recently completed an evaluation of 150 water systems supplying 189 temporary farm worker facilities. This effort was directed by the Governor and conducted in the summer and fall of 1999. This effort covered the entire state and included all active water systems serving temporary farm worker facilities except 16 to which DOH was denied access. Analysis of drinking water samples included volatile organic compounds (VOC), synthetic organic compounds (SOC), inorganic, nitrate ans bacteria. These systems are currently required to test regularly for only nitrate and bacteria. Only two systems (1%) contained organic chemicals (EDB) above drinking water standards. Approximately 20% of these system were in violation of the nitrate standard. Based on this finding DOH concluded that current testing requirements for these wells are sufficient. Recommendation #4 was modified in light of this report which is available on the Internet at "http://www.doh.wa.gov/water/final_report.htm" or by calling DOH at (360) 236-3110.

15. Why was the EPA data, which shows concentrations of 1,2-DCP as high as 52 ppb, not mentioned in this draft report? The fact that these high levels were detected, and that the boundaries of the contamination have never been defined and thus we do not by any means have a clear idea of the total population potentially affected, should be made clear in this report.

A level of 51.4 ppb 1,2-DCP was detected in a push-probe sample taken by EPA during their 1998 site investigation and will be noted Table 1. Most of the EPA groundwater samples taken during this investigation were extracted from push-probes as opposed to drinking water wells. Push-probes serve as temporary, single-sample monitoring wells. The data summarized in Table 1, (page 7) represents groundwater samples collected from drinking water wells between 1984 and 1999. The vast amount sampling data available for drinking water wells provided a good basis for estimating actual exposure.

As discussed in the Background section of the PHA (Part C. Nature and Extent of Contamination, page 6), it is likely that several groundwater contaminant plumes exist in north Whatcom County. Extensive sampling has been conducted by several state and federal agencies as well as private well owners that have helped to delineate the areas with the highest levels of pesticides in groundwater. Ecology has proposed to re-sample pesticide contaminated wells that do not currently qualify for an alternate water source (i.e., detections below one-half the MCL). Wells located near these areas of known contamination that have not yet been sampled will also be included in the plan.

16. Page 14. "There is little evidence, however, of such synergistic effects between chemicals..." I found statements of this type to be a problem throughout the document, in light of the fact that virtually NO testing of ANY nature has been done on the synergistic effects of chemicals. This type of statement is misleading, as it implies that testing HAS been done and no adverse effects have been found, when in fact we haven't done the testing and don't have any idea what the long-term synergistic effects are.

The issue of synergy between chemicals and the toxicity of chemical mixtures in general has received considerable attention in recent years. While the database for evaluating chemical mixtures is small, relevant studies are discussed in the Public Health Implications section of the PHA (Part D. Multiple Chemical Exposure, page 17). One such study exposed rats and mice to a mixture of contaminants in drinking water that included EDB, DBCP, 1,2-DCP and nitrate at levels much higher than those encountered in north Whatcom County groundwater. No adverse reproductive or developmental effects were noted. Reproductive toxicity has been identified as an endpoint of concern in animals given high doses of EDB and DBCP. In addition, developmental toxicity is often the most sensitive endpoint of chemical exposure. Therefore, this study provides good evidence that synergistic effects between the contaminants of concern in north Whatcom County groundwater are unlikely.

17. Page 16, "..cancer risk associated with pesticides at levels of health concern is likely overestimated. There is no evidence that this level of pesticide exposure can cause cancer in humans." What data is the first statement based on, that the risk is 'likely overestimated?" In the second sentence, here again it is implied that tests of low levels of pesticide exposure have been done and have shown no increase in cancer risk. Do we have conclusive evidence that low levels do NOT cause cancer? The Department of Health should endorse the precautionary approach.

The approach used in the PHA to estimate cancer risk relies on exposure assumptions that are used to calculate a dose. Since levels of contamination vary between wells, a "worst-case" evaluation was made assuming a 30-year exposure to the maximum detected levels of each pesticide (see Appendix B). This approach ensures that exposure will not be underestimated. However, no individual is or has been exposed at this level since the maximum pesticide levels are not found in the same well. In addition, a 30-year exposure will likely be incurred in only a small percent of the exposed population. Uncertainty accompanies both the exposure and toxicity

assessment components of the process. This uncertainty has made the "precautionary approach" inherent in the process of analyzing health risks associated with exposure to hazardous chemicals in the environment.

As noted in the response to Comment #1, statements noting the lack of evidence that a contaminant causes cancer in humans will be qualified.

18. Page 18. "..there is little evidence demonstrating this ...." Again, is there evidence proving the contrary?

Please see response to Comment #16.

19. Page 18, last paragraph begins by discussing toxic effects from interactions between chemicals. The bulk of the paragraph then tends to discount this finding, then the last sentence suggests that there may in fact be a reason for concern. The intervening statements between the first and last sentence should be removed, as they cloud the main point that there are interactions between chemicals and there is some evidence that adverse health effects result. Also, it is not relevant when talking about chemical mixtures that the chemicals were not those detected in Whatcom County – the point is about the effects of mixtures of chemicals.

Health risk assessment is fraught with uncertainty especially with respect to chemical mixtures. This paragraph provides an overview of the preceding discussion and how the available science relates to the exposures occurring in north Whatcom County. Addressing the uncertainties involved in risk assessment is vital in making an informed recommendation.

We respectfully disagree with the final statement "it is not relevant when talking about chemical mixtures that the chemicals were not those detected in Whatcom County". The recent study from the University of Wisconsin that found mild immunological effects in mice exposed to nitrate, atrazine and aldicarb is relevant. However, these pesticides differ from those found in north Whatcom County groundwater. Even small differences in chemical structure can significantly change the metabolism and toxicity of a chemical. Further, no reproductive or developmental effects were found in rats and mice exposed to chemical mixtures that included EDB, 1,2-DCP, DBCP and nitrate. Taken as a whole, this evidence does not indicate that nitrate and those pesticides found in north Whatcom County groundwater interact to produce a toxic effect.

However, the Wisconsin study is cause for concern since the exposure levels were not the traditional high dose variety but closer to what might actually be encountered in the environment. This fact generated Recommendation #6 that advises residents to consider reducing exposure when nitrate is present above the MCL along with detectable levels of pesticides. Infants and pregnant women should not drink any water with nitrate above the MCL.

20. Page 19. "Interactions between the pesticides found in north Whatcom County groundwater and nitrate are not of concern for reproductive or developmental endpoints. " What data exists to support this statement?

Please see response to Comments 16 and 19. This issue is also discussed in the Public Health Implications of the PHA (Part D. Multiple Chemical Exposure, page 17)

21. Page 20, first line. "...no evidence exists that chronic, low doses can impact humans." Again, is there data that shows that low doses do not impact humans?

This statement relates only to liver and kidney effects seen in animals at high doses and will be revised for clarity. As noted in the text, reproductive effects have been observed in workers exposed to EDB. However, these studies have limitations with respect to statistical power, exposure assessment and appropriate control groups. Please see response to Comment #1.

22. Page 25. Risks from current pesticide applications. The Department of Health should conduct a public health assessment from current pesticide applications. 1,2-DCP has been replaced by 1,3-DCP in most cases. Although not as persistent in groundwater, 1,3-DCP is more highly carcinogenic. This fact should be noted in the public health assessment, and a follow-up study should be done.

Please see response to Comment #3. Detections of 1,3-dichloropropane were infrequent and at low levels while 1,3-dichloropropene was not detected in either of the 1998 site investigations conducted by EPA and Ecology. The data do not warrant a follow-up study.

23. Page 33, number 43. "Natural degradation will slowly remove the pesticides..." It should be noted that this process may take decades to occur.

Responses to Community Health Concerns # 42 and 43 (page 33) will be modified accordingly.

24. Page 33, number 44. Why are attempts to get information on current products and quantities (of pesticide applications) "not yet successful"? This statement is very alarming. Pesticide application information should be readily available to the public and agencies. Relevant government agencies should take steps immediately to determine why this data is not immediately available. The Dept. of Health should perform a follow-up study regarding current pesticide/fertilizer applications after obtaining this data.

Please see response to Comment #7 for information on current pesticide use. Regarding a follow-up health study on fertilizer/pesticides exposure, Recommendation #7 (page 36) suggests that the issue of concurrent exposure to nitrate and pesticides be further examined. A health study examining the relationship between adverse health effects and exposure to nitrate and pesticides will require a much more detailed exposure assessment than mere application rates for a particular field. It is likely that any such exposed population will have to be studied on a state or regional

basis in order to obtain an adequate study population. It is important to note that the University of Wisconsin study is but one piece of information suggesting a further look into this type of exposure. In addition, this study looked at different pesticides, in conjunction with nitrate, than were found in north Whatcom County groundwater. It may be more appropriate for ATSDR to look at Midwest populations exposed to nitrate and those same pesticides.

25. Page 34. "...additional exposure of migrant farm workers to pesticides in soil and indoor dust is also cause for concern." There is a serious lack of data on this point. Dept. of Health should conduct a study of health risks to migrant workers and their families from exposure to pesticides and nitrate via multiple pathways.

Researchers at the University of Washington (UW) and other institutions have made significant contributions towards the understanding of worker exposure to pesticides including the indoor dust pathway. A current project by the UW is underway to determine the overall exposure of farm workers and their families to pesticides. This project will help to identify the pathways of greatest significance with respect to farm worker exposure (e.g., spray drift, soil contact, indoor dust). Recommendation #4 indicates the steps that farm workers can take to reduce their exposure to pesticides.

26. Page 35. "Farm workers should observe proper re-entry times for fields applied with pesticides." This places the burden on farm workers. It is not the decision of the farm workers as to when to re-enter a field.

Please see response to Comment #11.

27. Page 35. Dept. of Health should undertake a study of health risks to farm workers and their families from chronic exposure to pesticides and nitrate through multiple exposure pathways.

The University of Washington (UW) and the Fred Hutchinson Cancer Research Center are currently evaluating exposure of workers and their families to pesticides. This project is part of a larger effort by the UW to evaluate various environmental health issues under a grant from the EPA and the National Institute of Environmental Health Sciences. DOH currently evaluates discrete incidences of pesticide exposure to workers as part of the Pesticide Incidence Reporting and Tracking Review Panel.

The UW study will be helpful in discerning the major exposure pathways for farm workers. Concerning the evaluation of health effects as a result of nitrate exposure in combination with these multiple pesticide exposure, Recommendation #7 encourages such an effort. DOH has asked ATSDR's Division of Health Studies to consider whether such an effort is feasible and warranted.

28. Page 35. All wells in migrant farm worker camps should be tested yearly for pesticides and nitrate.

Please see response to Comment #14.

29. Page 37/38 – Action Plan. Dept. of Health should commit to studying synergistic effects of exposure to multiple chemicals, including farm workers and their families through multiple pathways.

Please see response to Comment #27.

30. Page 37/38 – Action Plan. Dept. of Health should undertake steps to conclusively determine the extent of the groundwater contamination in north Whatcom County.

Ecology is currently implementing another sampling plan (Phase III) to better determine the extent of groundwater contamination and the need for an alternate water source.

APPENDIX E: Current Pesticide Use on Raspberry Fields in Washington State

The information presented below in Tables A1 and A2 was obtained from the USDA Office of Pest Management Policy and the Pesticide Impact Assessment Program and is provided in response to questions raised about the current use of pesticides in north Whatcom County. This information is specific to raspberries as they are the major crop in north Whatcom County. More complete information regarding pesticide use on raspberries can be accessed on the Internet at "http://pestdata.ncsu.edu/cropprofiles/Detail.CFM?FactSheets__RecordID=55".

The reader should be aware that application rates will vary between growers. Table A2 provides a typical application profile for a grower targeting high-end markets such as produce. Growers selling to lower-end markets such as juice are expected to use about half of the fungicide estimated in Table A2. In addition, not all pesticides are applied annually. The soil fumigant 1,3-dichloropropene (Telone II®) is not listed in Table A2 because it is used only prior to planting and not on existing fields.

Table A1. Estimate of Usage of the Most Common Pesticides* in Raspberries in Washington State During the 1997 crop year

Pesticide	% Area treated	# Applications per year	Lb. AI/acre per application	Lb. AI/treated acre per season
Insecticides				
»»Bifenthrin**	81	1.0	0.10	0.10
Bt	46	2.1		
»»Diazinon	77	1.4	1.10	1.54
Esfenvalerate	36	1.0	0.06	0.06
»»Malathion	44	1.0	1.07	1.07
Fungicides				
»»Benomyl	76	1.7	0.49	0.83
»»Captan	94	5.0	1.17	5.85
Ferbam	61	1.3	1.23	1.60
Iprodione	71	1.3	0.60	0.78
»»Lime Sulfur	70	1.0	9.16	9.16
»»Metalaxyl	49	1.2	0.49	0.59
Vinclozolin	58	2.6	0.54	1.40
Herbicides * **				
»»Diuron	31	1.0	0.97	0.97
Norflurazon	4	1.0	1.20	1.20

Pesticide	% Area treated	# Applications per year	Lb. AI/acre per application	Lb. AI/treated acre per season
»»Oryzalin	62	1.0	1.20	1.20
»»Oxyfluorfen	74	1.0	0.10	0.10
»»Paraquat	85	1.1	0.32	0.35
Sethoxydim	5	1.0	0.19	0.19
»»Simazine	56	1.1	0.62	0.68

Source: Adapted from the National Agriculture Statistics Service, USDA Pesticide Data Program, Fruit summary for the 1997 Crop Year. URL: http://www.usda.gov/nass/pubs/estindx1.htm#agchem

* Limited to pesticides used to control insects, diseases, and weeds only.

** Materials shown in red or marked with this symbol (»») are heavily relied upon and have few or no currently registered and effective substitutes.

*** Discrepancies in rates between this table and text in the weed control section are due to different methods of reporting. The text shows labeled rates per acre. Because these materials are typically applied in 3-4 ft. wide bands in the row, actual use per acre is 30-40% of the labeled/broadcast rate as shown here.

Table A2. Typical Pesticide Spray Program for the Year On an Average Farm

Date	Pesticide	Lbs ai/acre	Method	Target Pest*	Crop Stage
March	Diazinon	2.0	Banded	Crown borer	Dormant
	Diuron	1.6-2.4	Banded	Weeds	Dormant
	Metalaxyl	0.5	Banded	Root rot	Dormant
Late March	Lime Sulfur	9	Foliar	Cane diseases	Delayed dorm.
Early April	Oxyfluorfen	0.1	Directed base	Cane burn	Pre-bloom
Early May	Captan	2.0	Foliar	SB	Pre-bloom
Mid May	Captan	2.0	Foliar	SB	Early Bloom
	Iprodione	0.5	Foliar	Botrytis, SB	Early Bloom
	Diazinon	1.0	Foliar	Fruitworm	Early Bloom
Late May	Captan	2.0	Foliar	Botrytis, SB	Bloom
Early June	Captan	2.0	Foliar	Botrytis, SB	Bloom
	Vinclozolin	0.5	Foliar	Botrytis	Bloom
Mid June	Captan	2.0	Foliar	Botrytis, SB	Bloom
Late June	Captan	2.0	Foliar	Botrytis, SB	Pre-Harvest
	Iprodione	0.5	Foliar	Botrytis, SB	Pre-Harvest
	Bifenthrin	0.1	Foliar	Insects	Pre-Harvest
August	Benomyl	0.375	Foliar	Cane blight	Post-Harvest

Date	Pesticide	Lbs ai/acre	Method	Target Pest*	Crop Stage
	Fenbut. Oxide	1.0	Foliar	Spider Mites	Post-Harvest
October/Nov	Fenamiphos	6.0	Banded	Nematodes	Post-Harvest

Source: WSU Vancouver, Lynden Satellite Station IPM Project (1998) and personal communication with raspberry growers

*Target pest codes where abbreviated:

- Crown borer: Raspberry Crown Borer, *Pennisetia marginata*
- Root rot: primary target is *Phytophthora fragariae* var *rubi*
- Cane burn: Primocane suppression
- SB: Spur Blight, *Didymella applanata*
- Botrytis: Gray mold fruit rot; *Botrytis cinerea*
- Insects: Adult root weevils and miscellaneous harvest- contaminating insects and spiders
- Nematodes: Root Lesion Nematodes, *Pratylenchus* spp.

GLOSSARY

Acute
Occurring over a short time, usually a few minutes or hours. An acute exposure can result in short-term or long-term health effects. An acute effect happens a short time (up to 1 year) after exposure.

Aquifer
Water-bearing rock or rock formation located beneath the ground surface.

Carcinogen
Any substance that may produce cancer.

Chronic
Occurring over a long period of time (more than 1 year).

Concentration
The amount of one substance dissolved or contained in a given amount of another. For example, sea water contains a higher concentration of salt than fresh water.

Contaminant
Any substance or material that enters a system (e.g., the environment, human body, food, etc.) where it is not normally found.

Dermal contact
Contact with the skin. Refers to absorption through the skin as a route of exposure.

Dose
The amount of substance to which a person is exposed. Dose often takes body weight into account.

Downgradient
Refers to a location toward which groundwater will flow.

Exposure
Contact with a chemical by swallowing, breathing, or direct contact (such as through the skin or eyes). Exposure may be short term (acute) or long term (chronic).

Exposure Pathway
An exposure pathway is the process by which an individual is exposed to contaminants that originate from some source of contamination. It consists of five elements: 1) Source of Contamination, 2) Environmental Media/Transport, 3) Point of Exposure, 4) Route of Exposure and 5) Receptor Population.

Groundwater
Water contained in the spaces between soil and rock below the water table. This water can be in shallow (overburden) aquifers or bedrock aquifers.

Ingestion
Swallowing (such as eating or drinking). Chemicals can get into or on food, drink, utensils, cigarettes, or hands where they can then be ingested. After ingestion, chemicals can be absorbed into the blood and distributed throughout the body.

Inhalation
Part of the breathing process. Exposure can occur by inhaling contaminants which can then be deposited in the lungs, taken into the blood, or both.

Lowest Observed Adverse Effect Level (LOAEL)
The LOAEL is the lowest dose at which an adverse health effect is seen in a particular study. The LOAEL is often used to derive MRLs and RfDs.

Maximum Contaminant Level (MCL)
The MCL is a regulatory limit set by the Environmental Protection Agency (EPA) for contaminants in drinking water. If an MCL is exceeded, regulatory action is required under the Safe Drinking Water Act. MCLs are not always strictly health based but can consider technological or economic feasibility.

Media
Soil, water, air, plants, animals, or any other parts of the environment that can contain contaminants.

Minimal Risk Level (MRL)
Minimal Risk Levels (MRLs) are levels of chemical exposure below which non-cancer effects are not expected. MRLs are derived by the Agency for Toxic Substances and Disease Registry. An MRL is derived by dividing a LOAEL or NOAEL by "safety factors" to account for uncertainty and provide added health protection..

National Toxicology Program (NTP)
NTP conducts toxicological testing on those substances most frequently found at sites on the National Priorities List of the EPA, and which also have the greatest potential for human exposure.

No Apparent Public Health Hazard
A conclusion category used when human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

No Observed Adverse Effect Level (NOAEL)
The NOAEL is the highest dose from a study that did not find any adverse health effects. The NOAEL is often used to derive MRLs and RfDs.

No Public Health Hazard
A conclusion category used when data indicate that no current, past or potential for future exposure exists and, therefore, no health hazard exists.

Oral Reference Dose (RfD)
Oral Reference Doses (RfDs) are levels of chemical exposure, derived by the Environmental Protection Agency, below which non-cancer effects are not expected. An RfD is derived by dividing a LOAEL or NOAEL by "safety factors" to account for uncertainty and provide added health protection

Plume

An area of chemicals in a particular medium, such as air or groundwater, moving away from its source in a long band or column. A plume can be a column of smoke from a chimney or chemicals moving with groundwater.

Potential/Indeterminate Public Health Hazard

A conclusion category used when no conclusions about public health hazard can be made because environmental and/or toxicological data are lacking.

Public Availability Session

An informal, drop-by meeting at which community members can meet one-on-one with state health department and ATSDR staff members to discuss health and site-related concerns.

Public Health Assessment

The evaluation of data and information on the release of hazardous substances into the environment in order to assess any current or future impact on public health, develop health advisories or other recommendations, and identify studies or actions needed to evaluate and mitigate or prevent human health effects; also, the document resulting from that evaluation.

Public Health Hazard

Sites that pose a public health hazard as the result of long-term exposures to hazardous substances.

Receptor Population

Persons who are exposed or potentially exposed to the contaminants of concern at a point of exposure.

Risk

In risk assessment, the probability that something will cause injury, combined with the potential severity of that injury.

Route of Exposure

The way in which a person may contact a chemical substance. For example, drinking (ingestion) and bathing (skin contact) are two different routes of exposure to contaminants that may be found in water.

Shallow aquifer

Sub-surface water-bearing area that lies between the water table and bedrock characterized by loose soil, sand, gravel, etc. Also known as the overburden.

Source

Origin of a contaminant release into the environment, or, if the source is unknown, the environmental media through which contaminants are presented at a point of exposure.

Volatile Organic Compounds (VOCs)

Substances that easily become vapors or gases and contain carbon and different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen. Many VOCs are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry cleaning fluids).

CERTIFICATION

This Whatcom County Groundwater Public Health Assessment was prepared by the Washington State Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and occurs with the findings.

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